GOLDEN ANNIVERSARY

"Forward... From 50"

THIRTY-THIRD ANNUAL TECHNICAL SYMPOSIUM

TECHNICAL PAPERS

Sponsored by the
ASSOCIATION OF SCIENTISTS & ENGINEERS
of the NAVAL SEA SYSTEM COMMAND

Friday, 26 April, 1996

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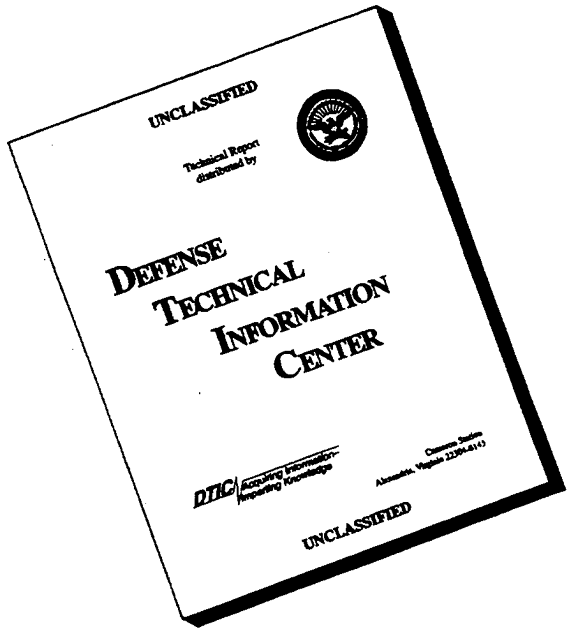

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ASSOCIATION OF SCIENTISTS AND ENGINEERS
OF THE NAVAL SEA SYSTEMS COMMAND
Post Office Box 15864
Arlington, Virginia 22215

26 April 1996

Welcome to the 33rd Annual Technical Symposium and Banquet of the Association of Scientists and Engineers of the Naval Sea Systems Command. This is ASE's 50th year of service to our membership and the Command. The Symposium is the premier event of our activity year and continues a proud tradition of providing our membership with professional growth opportunities.

The Professional Development Committee has put together a strong technical program covering the broad spectrum of Command responsibilities. The theme this year is "Forward ...From 50". The program consists of sixteen papers in four sessions entitled "Ships for the 21st Century," "Acquisition Reform," "Designing for the Future," and "Management and Logistics." The paper topics cover oceanographic research ships, surface combatants, amphibious assault ships, cooperative engagement, oversite and review, integrated product teams, integrated product process development, system safety, commercialization, damage control, human engineering, ship habitability, electromagnetic engineering, management information systems, test and evaluation, occupational health, and regionalization. This is truly a program spanning the interests of the ASE membership as well as the mission of the Command.

At the Banquet, we are most pleased to have with us Vice Admiral George R. Sterner, Commander Naval Sea Systems Command, who will present his "View From The Bridge." We are also honored to have as our featured guest speaker, Vice Admiral Thomas J. Lopez, Deputy Chief of Naval Operations (Resources, Warfare Requirements and Assessments). Mr. Paul Anthony returns again this year to serve as our Master of Ceremonies.

The ASE Symposium Committee has done a superb job in planning and preparing for this event. We are proud to have the opportunity to serve our membership, our profession, and our Command. We trust you will enjoy the fruits of our labor.

GOLDEN ANNIVERSARY
1946 1996
"Forward... From 50"

Sincerely,

Edward N. Comstock,
President, Association of
Scientists and Engineers

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R/V ATLANTIS: A NEW MOTHERSHIP FOR ALVIN

Dan Rolland, John J. McMullen Assoc., Inc
Steve Hannuksela, Closures, Outfitting, and Submersibles Branch, Naval Sea Systems Command
Thomas Demas, Program Executive Office, Carriers, Littoral Warfare and Auxiliary ships

Abstract

With the approach of the 21st century, the vast ocean depths remain this planet's final frontier. Over the last 30 years, scientists have used a variety of tethered and autonomous underwater vehicles to make significant discoveries which enhance our understanding of the environment. The United States Navy has been a leader in deep submergence science with a number of manned submersibles. The most famous of these is the venerable Deep Submergence Vehicle (DSV) ALVIN which is operated by the Woods Hole Oceanographic Institution (WHOI). ALVIN is owned by the U.S Navy Office of Naval Research (ONR) and is operated under an agreement among ONR, National Oceanic and Atmospheric Administration (NOAA), and the National Science Foundation (NSF). For the last 30 years, ALVIN has maintained an unparalleled record of service and reliability which has kept the U.S. at the forefront of ocean research. Despite current tendencies toward reduced federal funding for science research, interest in manned deep submergence remains high and ALVIN is expected to continue at the forefront of the investigation of the global ocean's inner space.

One of the most important factors in ALVIN's record of excellence and reliability is a capable support ship. The present support ship, ATLANTIS II or AII, is nearing the end of her useful life and must be retired. In the Spring of 1996, while ALVIN is undergoing a periodic overhaul, the new construction Research Vessel (R/V) ATLANTIS (AGOR 25) is planned to become the new support vessel which will carry ALVIN well into the 21st century. This paper explores the challenging design considerations of significantly modifying a ship's mission during construction without severely impacting delivery and without losing the ship's original mission capabilities. This paper discusses the innovative and versatile features which will improve the support capability for ALVIN. The paper also addresses the significant efforts made to adapt the rigorous Navy submersible handling certification requirements to a commercial acquisition philosophy.

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Notations/Definitions/Abbreviations

ABE	Autonomous Benthic Explorer
ABS	American Bureau of Shipbuilding
AGOR	Auxiliary General Oceanographic Research
AUV	Autonomous Underwater Vehicle
BT	Bathythermograph
DSRV	Deep Submergence Rescue Vessel
DSS	Deep Submergence Systems
DSV	Deep Submergence Vehicle
FMECA	Failure, Modes & Effects and Criticality Analysis
HMI	Halter Marine, Inc.
INSURV	U.S. Navy Board of Inspection and Survey
NAVSEA	Naval Sea Systems Command
NDT	Non Destructive Testing

NOAA	National Oceanic and Atmospheric Administration
NSF	National Science Foundation
ONR	Office of Naval Research
R/V	Research Vessel
ROV	Remotely Operated Vehicle
SOC	Scope of Certification
SUBSAFE	Submarine Safety
UNOLS	University National Oceanographic Laboratory System
WHOI	Woods Hole Oceanographic Institution

Introduction

The name ATLANTIS has been prominent in the WHOI research fleet since 1931. The Institution's first research vessel, a 142-foot steel-hulled ketch named ATLANTIS, had a long and distinguished career. She sailed on 299 cruises over more than a half million miles between 1931 and 1964 to support U.S. Navy and other oceanographic research projects. Among her many contributions was the first major study of underwater acoustics which led to the development of the bathythermograph (BT) for use by submarines and surface vessels during World War II. The BT later became the standard tool for oceanographers worldwide. ATLANTIS, affectionately called the A-boat, was retired from the WHOI fleet in 1964 and sold in 1966 to the Government of Argentina, where she is still pursuing limited oceanographic research under the name EL AUSTRAL. Her contributions to marine science and exploration have not been forgotten, however, and were given special national recognition when NASA named the Space Shuttle ATLANTIS in the vessel's honor.

The ATLANTIS tradition continued when the 210-foot ATLANTIS II, or AII, joined the WHOI fleet in 1963 as a replacement for ATLANTIS. Considered the first of the United States' modern oceanographic research vessels, AII has had an equally distinguished career with contributions in all areas of oceanography. The ship has sailed throughout the world's oceans pioneering studies in marine geology and geophysics, air-sea interaction, and deep-sea surveying and imaging. In 1983, AII became the support vessel for the three-person Deep Submergence Vehicle (DSV) ALVIN. Together, the ship and submarine have made countless contributions, furthering our understanding of the seafloor and the water column above it through studies in all areas of ocean science and engineering.

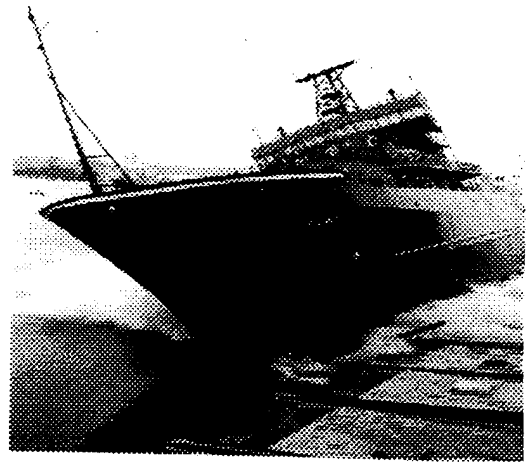

Figure 1 Photo of new ATLANTIS launch

With the retirement of AII planned for 1996, the science community has anxiously searched for a suitable replacement. That search recently culminated in selection of the latest ship to bear the name ATLANTIS. This ship is the first in the U.S. Navy academic fleet to be built as a platform for both manned and unmanned deep-sea exploration. She was launched in Pascagoula, Mississippi, February 1, 1996, figure (1). The 274-foot Research Vessel ATLANTIS will be among the most sophisticated research ships afloat, capable of supporting both submersible operations and general purpose oceanographic research throughout the world.

ALVIN and the Deep Submergence Operations Group

The Deep Submergence Group

The Deep Submergence Operations Group at WHOI is the organization responsible for operating ALVIN. It was established in 1961

by Allyn Collins Vine, a WHOI geophysicist who felt strongly that submarines should be used for research. Vine believed ocean scientists ignored the submarine for their research. Since no other research institutions were interested in using a submarine for ocean science, including the Navy, Vine established a group at WHOI. His hopes were that this group might operate a submarine for ocean research. Vine was interested in the TRIESTE, bought by the U.S. Navy from Italy to train pilots. He was also exploring a joint venture with a company willing to build a submarine. Vine worked with the Reynolds Metals Company, who was willing build a submersible and lease it to WHOI for ocean research. With WHOI's assistance, the Reynolds Company began the design and construction of an aluminum deep-diving submarine called the ALUMINAUT.

At roughly the same time, General Mills Company was pursuing their own deep-diving vessel design, called the SEAPUP. Vine and his deep submergence group liked the SEAPUP design and its affordable price tag of $225,000. The Deep Submergence Group considered the SEAPUP as an interim craft, something small and inexpensive that could be used while the ALUMINAUT was being built. But after consideration they realized that the SEAPUP could be a better submarine, since the SEAPUP design was considerably smaller than the ALUMINAUT and it corrected many problems found in the TRIESTE design.

History of ALVIN and Her Mother Vessel

ONR realized the SEAPUP*'s* potential too and asked WHOI to use funds, formally authorized to buy the ALUMINAUT, for SEAPUP. In 1961, General Mills was awarded a contract to build the SEAPUP. During the vessel's construction the Deep Submergence Group oversaw its design. It was the Deep Submergence Group who first thought that Vine looked like Alvin the chipmunk, a popular cartoon during the 1960s. In fact, they began calling the SEAPUP ALVIN, after Al Vine, since it was he who had the vision for a submarine to be used in ocean science. Once the Deep Submergence Group began calling the submarine ALVIN, the name stuck and on June 5, 1964 the submarine was officially commissioned the ALVIN. Its final price tag was $950,289. For the next 30 years, Alvin would maintain an unparalleled record of service and reliability, keeping the U.S. at the forefront of ocean research. Over the years, ALVIN has slowly evolved and now sports a titanium sphere that carries a pilot and two scientific observers to depths of 15,000 feet (4,500 meters). Constant improvements in technology have brought better maneuverability, and increased reliability, efficiency and performance.

Once ALVIN was commissioned, WHOI began looking for a mother vessel which could safely deploy the submarine on a regular basis. WHOI believed the mother ship for ALVIN should be a catamaran, with sufficient space between the hulls for launch and recovery. WHOI was counting on ONR for the funding, but there was not enough money to build the proper mother ship. The first mother ship for ALVIN was acquired in pieces from the Navy. Two moth-balled, 96 foot pontoons, built for mine-sweeping and connected with two steel arches spanning 50 feet. One of the pontoons held the machinery and the other contained the living quarters. ALVIN was placed mid-deck on a cradle and lowered by winch for launch and recovery. The catamaran required another ship to tow it between locations and provide whatever other amenities were needed for life at sea. The catamaran mother ship was named LULU after Al Vines's mother Lulu Vine. A photo of the LULU is shown in figure (2). Over the years, modifications were made, including a permanent bridge house and a propulsion system which enabled LULU to travel at a speed of 3 knots in calm water. A typical launch and recovery took virtually all hands, including the galley staff and members of the scientific party. While the skipper steered LULU, at least ten people handled the lines from the pontoons. Two were in the whaler to fetch the escort swimmers and the second pilot motored ALVIN out. An engineer lowered and raised the cradle while someone stood with a pipe at the hoist to poke apart the

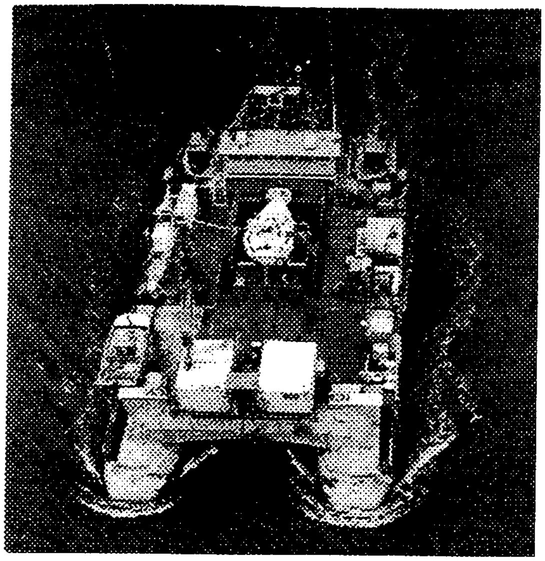

Figure 2 Photo of LULU

chains when they overlapped. It was crude, but this handling system operated successfully for over 18 years.

The History and Status of ATLANTIS II

By 1982, LULU was suffering increasing mechanical problems which affected ALVIN's research. WHOI began looking for a replacement and alternatives were KNORR (AGOR 15) or Scripps Institute's MELVILLE (AGOR 14), both of which were designed and built in 1969 to accommodate a submersible. Their larger decks could accommodate ALVIN, but both ships already sat a foot and a half deeper in the water than they should have. Furthermore, the side crane on KNORR which was meant to handle a submersible, never met the requirements for lifting a sixteen ton submarine. WHOI owned another vessel, the AII, which had much less room than KNORR and an even worse weight problem. As WHOI pondered the dilemma, NSF warned of funding cutbacks for the research ships. It was almost certain a vessel would be laid up, and WHOI believed it would be the AII. In an act of desperation, the AII was selected as the mothership, the oldest ship in the academic fleet.

The AII was delivered to WHOI a year before ALVIN. By 1982, she was ready for a mid-life

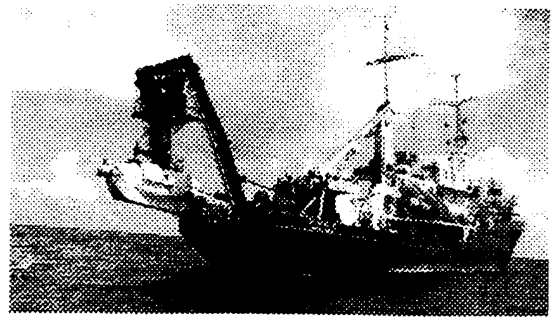

Figure 3 Photo of AII

refit and the timing was perfect. The most promising launch system for the AII was determined to be a stern mounted A-Frame used primarily by the offshore oil industry. With NSF funds, the AII was renovated and fitted with an A-Frame made by the Scottish firm Caley Hydraulics, LTD, now Caley Ocean Systems. There were no parts of ALVIN that the A-Frame could attach to, so a titanium T-bar hitch post became an integral part of the submarine. The AII shown in figure (3), is 210 feet long, twice LULU's length, and carries berths for fifty personnel. The *AII* has operated successfully for 13 years and is one of the most important factors in ALVIN's record of excellence and reliability. However, now the vessel is nearing the end of her useful life and must be retired.

The Search for a New Support Ship

The search for a replacement support ship concentrated on conversion of an existing ship because of budget constraints. The first candidate considered for conversion was once again the KNORR. This ship has been operated continuously by WHOI in a wide variety of oceanographic research programs around the globe. In 1991, KNORR underwent a major overhaul, including hull lengthening, and her anticipated life was extended to at least 15 years. A detailed conversion study was performed in late 1994 to assess the feasibility of carrying ALVIN on KNORR. The study concluded that converting the KNORR would certainly be feasible and, because of her size, would provide a significant improvement in handling facilities over those currently available on AII. However, the cost for the conversion

was considered high, so the search was continued.

AGOR 25 Design Modifications

Feasibility Study of R/V ATLANTIS (AGOR 25)

In April of 1995, ONR requested NAVSEA perform a feasibility study for the conversion of the new ATLANTIS (AGOR 25), currently under construction at Halter Marine Inc. in Moss Point, Mississippi. Conversion of a new ship offered a number of advantages that interested the science community - modern design features, spacious laboratories, and, perhaps most importantly, a 30 year plus service life expectancy. Also, it was hoped that, because ATLANTIS was still under construction, the conversion would require less ripout and would be less expensive than KNORR. The feasibility study was performed and concluded *Alvin* could be accommodated with acceptable impact to the ship's other mission capabilities. The 150 ton plus weight impact associated with handling ALVIN could be accommodated on the ship by deleting some main deck and storeroom mission load allowances. AGOR 25 is designed with a large allowance for scientific loads both on the Main Deck (100 tons) and in the below deck science storage compartments (75 tons). The ship's existing staging bay could be easily enlarged to provide a hangar for ALVIN.

Development of Requirements

After the feasibility study concluded that ALVIN could be accommodated on AGOR 25, ONR decided to pursue the matter further and requested NAVSEA authorize the shipyard to develop a more detailed design and a cost estimate. The first step in developing a design was to establish detailed requirements. This was done by soliciting information from Woods Hole personnel on their needs and by visiting the AII to see the existing operation. At the outset, it was realized that the facilities on AII needed significant improvement in some areas.

In order to understand the requirements for ALVIN support, it is best to summarize the support functions required for day-to-day operation. When the ship is on an ALVIN mission, dives are typically conducted every day. When aboard the ship, ALVIN sits inside the hangar for protection from the elements and to provide a comfortable working environment for maintenance personnel. For launching, the submarine is moved aft along a pair of rails to a position under the A-frame. A large hoisting line is looped over ALVIN's T-fitting and the submarine is lifted from the deck. The A-frame is boomed aft over the stern and the hoisting line is lowered until the submarine is afloat in the water. Swimmers, who ride along on top of ALVIN, release the hoist line and the submarine begins the dive. After the dive, which may last from 3 to 12 hours, the submarine surfaces within a mile or so of the ship. The ship then maneuvers so that the submarine is astern and the ship's bow is into the weather. A line from a stern-mounted tow winch is attached and the submarine is winched toward the stern of the ship. The swimmers attach the hoisting line and the submarine is lifted back onto the deck and moved back into the hangar.

After a dive, the ALVIN team must perform all required service to ready the submarine for the next dive, usually the next day. The batteries on the submarine must be checked and recharged. A thousand pounds of expendable steel plate ballast weights must be installed in special racks on the sides of the submarine. This ballast is stored below deck and must be lifted up to the Main Deck by mechanical or human means. Auxiliary systems must be checked. Hydraulic oil must be checked. Pressure compensating oil must be replenished. An interior dehumidification system must be inserted into the submarine pressure sphere to dry it out and protect equipment from moisture damage.

Cross decked equipment

Some of the equipment on AII will be cross-decked or moved to the new ATLANTIS because it is either still serviceable or is specialized and not easily replaceable. The

most important item is the large A-frame which is used to launch and retrieve ALVIN over the stern. This A-frame is designed to handle the 40,000 lb submarine while personnel are still board, a requirement which imposes extensive safety provisions. In addition to the travel forward and aft, the A-frame also has a large hydraulic hoisting winch at its top for lifting the submarine from the water. The winch has a length of polyester lifting hawser with an eye in the end which is looped over a T bar on the top of the submarine. The A-frame has motion compensators on it to stabilize the submarine when the ship is rolling and pitching. The A-frame will be modified with a new electrohydraulic control system and new two-speed valves which will be added to the winch motors. Other cross-decked equipment includes auxiliaries such as battery chargers, oxygen generating and storage equipment, an air compressor, and assorted electronics to assist the ALVIN surface controller.

Improvements to existing capability on AII

The ALVIN operation on AII, while certainly commendable in efficiency and reliability, was in need of improvement in several areas. One area of improvement was in deck rails and transporter used to move ALVIN from the hangar to the launching position under the A-frame. Figure (4) shows the improved rails and

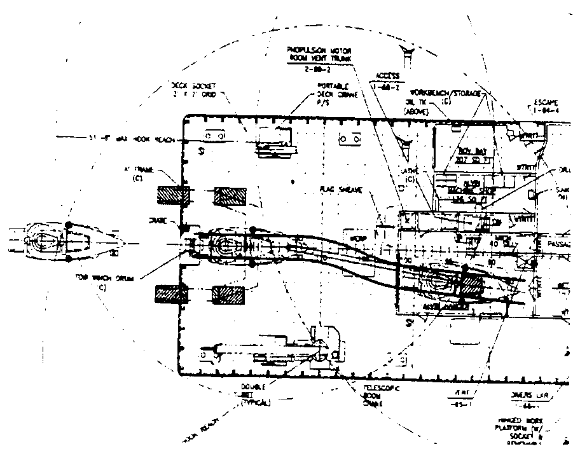

Figure 4 Improvements in Rails & Transporter

transporter. The present system allows very little space under the submarine for maintenance. The new system will raise the submarine higher off the deck to allow more access for maintenance activities. A second area of improvement is installation of a battery lift which will enable easier changing of batteries both in port and at sea if necessary. The existing system on AII can be used only in port and consists essentially of a pair of manually-operated chain falls. The batteries are

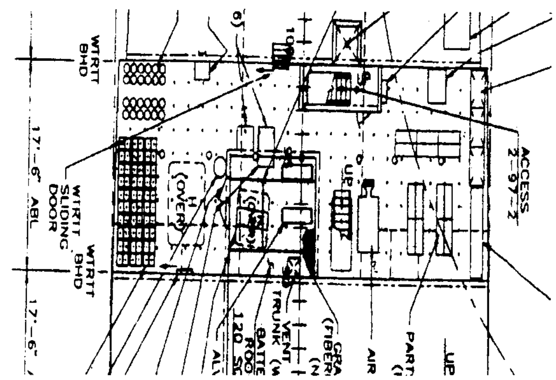

Figure 5 Arrangement of Battery Room

very heavy and require some "wiggling" in order to insert them up into their snug-fitting compartments in the bottom of the submarine. The chain fall operation is very tedious and dangerous to personnel. It also requires absolutely calm conditions to perform. A battery failure during a mission means an early return to port and the loss of valuable science time. The new system on ATLANTIS will have a powered lift mechanism and an X-Y translation table for positioning the battery in the submarine. This powered lift will also be suitable for bringing up steel ballast from below deck. An arrangement of the Battery Room is shown in figure (5).

A new towing winch will be mounted on the stern of the ship and used to pull ALVIN in towards the stern to the lifting position. This winch is located just below the level of the main deck in order to exert a nearly horizontal pull on the submarine. ATLANTIS will also have new spacious shop facilities dedicated to ALVIN support. These facilities are located in new spaces on the main deck, so there is no loss of existing laboratory space. A new remotely operated vehicle (ROV) hangar will also be located on the main deck port side. This will allow the important and rapidly developing

ROV and autonomous underwater vehicle (AUV) capabilities to have a permanent facility, rather than a van to work out of. An additional hydroboom is located on the port side to launch and retrieve equipment.

Schedule Issues

Although conversion of a brand new ship offered significant benefits, it also presented some difficult schedule challenges. Because of the desire to minimize the down time for ALVIN, a paramount concern was arranging the ship conversion so that it would coincide with the mandatory major overhaul and inspection required for ALVIN in late 1996 or early 1997. Delaying the start of the conversion until ship delivery in April 1997 would result in an unacceptable downtime for ALVIN of possibly 8 months or more. Therefore, the only alternative acceptable to the science community was to attempt conversion of the ship at the building yard before delivery. A difficult negotiation exercise followed in order to ensure that: 1) contractual obligations for the original ship were fulfilled; 2) important delivery events such as U.S Navy, Board of Inspection and Survey (INSURV) acceptance trials, fitting out availability, post delivery availability, and mission equipment demonstrations were included; and 3) the shipyards other programs, both Government and commercial, were not impacted. The agreed upon schedule will have the shipyard installing most of the ALVIN equipment prior to acceptance trials. The ship will then complete the trial process with a partial ALVIN installation and then proceed to another shipyard facility for completion of the ALVIN work. After completion of the ALVIN work, the ship will be readied for sea, fitted out with necessary science and mission equipment, and depart for mission demonstrations. After mission demonstrations, the ship will transit to WHOI where ALVIN will be put on board.

Certification

Background of Navy Handling System Certification

One of the most challenging aspects of the conversion of this brand new ship was in the certification of the handling system. Physical construction of the ATLANTIS was more than 50 percent complete before the decision was made to install the ALVIN handling system. Furthermore, The ATLANTIS was being built to commercial standards, and the shipbuilder was unfamiliar with military standards and Navy certification practices and procedures. The Navy insisted that a U.S. Navy certification applied to ALVIN and the new ATLANTIS because, through ONR, the Navy paid to develop and build ALVIN back in the early 1960s, and continues to pay a large part of their operating budget today. The objective of Navy certification for the handling system on board the ATLANTIS is to verify to ONR that the A-frame will be refurbished, modified, installed and tested in accordance with acceptable materials, standards, and procedures.

Navy Certification got its start as a result of the THRESHER sinking. The Navy developed the Submarine Safety (SUBSAFE) program for submarines, and the Certification Program for "Non-Combatant" submarines, i.e., manned submersibles or Deep Submergence Vehicles as they are called in the Navy. ALVIN was the first submersible to obtain Navy certification. and was granted certification in 1964. The Navy certifies the safety of Deep Submergence Systems (DSS) and diving systems. DSS include underwater vehicles such as manned submersibles, atmospheric diving suits, and swimmer delivery vehicles.

DSS and diver handling systems have been certified by the Navy for over 20 years. Although the Navy was involved with placing land-based cranes on board commercial offshore support vessels in the late 1960s to launch and recover the manned submersibles SEA CLIFF and TURTLE, the first handling system to be certified was on the ELK RIVER *(IX 505)*, a saturation diving training platform, in the early 1970's. Since then, many handling systems have been certified. They range in size from an elevator that was on board the ASR 21 class submarine rescue ships, USS PIGEON (ASR 21) and USS ORTOLAN (ASR 22) to launch and recover the 90,000 pound Deep

Submergence Rescue Vehicles MYSTIC (DSRV 1) and AVALON (DSRV 2), to an A-frame on board a modified LCM-8 to launch and recover a 900-pound Atmospheric Diving Suit. The elevators on board the ASR 21 class ships were also used to deploy and recover a saturation diving bell and a Submarine Rescue Chamber. Other handling systems certified by the Navy include an A-frame designed for 87,500-pounds (another Caley A-frame), an elevator designed for 103,000-pounds (both of these are on modified offshore support vessels manned by civilians), and divers davits on board the ARS 50 class salvage ships.

Purpose of U.S. Navy Certification

The purpose of Navy certification is twofold. First, when the DSS or dive system is new, certification assures the design, fabrication, installation, and testing is in accordance with recognized standards and methods. Secondly, after the DSS or dive system has been deployed, it assures that it is operated, repaired, and maintained safely, adequately, and in accordance with procedures provided by the designers and manufacturers. The intent of the Navy certification process is to provide a maximum reasonable assurance that a failure in the system will not cause an injury to an occupant of the DSS. It also establishes maximum reasonable assurance that the DSS occupants or diver(s) can be recovered without injury if there is an accident.

The final authority for granting system certification for DSS is NAVSEA, Deputy Commander for Submarines, SEA 92. The code within NAVSEA for the DSS certification process is the Submarine Safety and Quality Assurance Division, SEA 92Q. However, Director of Ocean Engineering, Supervisor of Salvage and Diving, SEA 00C, is responsible for the certification of diving systems. The technical point of contact in NAVSEA for DSS and diver handling systems is the Closures, Outfitting and Submersibles Branch, SEA 03W14.

Comparison of U.S. Navy and American Bureau of Shipbuilding (ABS) Requirements

In obtaining certification for the ATLANTIS, a comparison of ABS and Navy requirements was made. Technical requirements for design, testing and documentation for the Navy and ABS were found to be basically the same, with some exceptions. Both require the following: a Failure, Modes and Effects and Criticality Analysis (although the Navy requires a System Safety Analysis, which includes much more than a FMECA); design analyses, power and control system schematics, hydraulic schematics, fabrication design considerations; and operability and maintainability considerations. Both also require structural, electrical and hydraulic tests to be accomplished. However, the Navy requires a higher dynamic load test than ABS; 150% of the rated load versus 125%.

The biggest difference between Navy and ABS requirements for handling systems is that the Navy does not automatically include every component of the handling system in the Scope of Certification (SOC). Scope of Certification is a Navy term. It comprises those systems, subsystems and components, and their associated maintenance and operational procedures required to ensure the safety and well-being of the personnel inside the DSS or diving system. For Navy certification, only those portions of the handling system that are load bearing and/or load controlling are included in the SOC. For example, the SOC for the elevator handling system used to launch and recover the DSRVs include the elevator structure, wire ropes, and wire rope reeving components. The hydraulic power unit and electrical components are not in the SOC. If any of these components were to fail, personnel inside the DSRV would not be in any danger. Whereas on the ATLANTIS A-frame, much of the electrical and hydraulic components are within the SOC, as are the structural components and main lift line, because they are used for ship motion damping purposes. The design of all items within the SOC must be reviewed and approved by the Navy. The design of all other components may be reviewed

by Navy, but the rigorous quality assurance requirements do not apply. The design and capability of the components outside the SOC are qualified during load and qualification tests. ABS Rules, on the other hand, are always applied to the entire handling system. This is satisfactory to civilian shipyards because they are very familiar with ABS procedures.

Another major difference is that the Navy is concerned with ensuring DSSs and diving systems are materially and procedurally adequate. The term "materially and procedurally adequate" means that anything that may be used in developing items within the SOC, and their operability and maintainability functions, must be sufficient and verifiable. Examples of what is meant by being materially and procedurally adequate are: (1) ensuring the factors of safety are in accordance with design criteria. It must be verified that the material used in the DSS or diving system is the same as is specified on the drawings and in the calculations. This is especially true if high strength steels or exotic metals are used; (2) welder qualifications and approved welding procedures must be verified. Also, that Non Destructive Testing (NDT) inspectors are qualified and their machines are within calibration; (3) verifying that there is a way of controlling material as it comes into and flows through the yard; and (4) ensuring operational, maintenance, and emergency procedures have been established, and are in place.

ABS does not look at the documentation between the design reviews and the as-built configuration on the ship unless there is a specific requirement to do so. They concentrate most of their efforts in the design and testing phases, as well as operability and maintainability of the handling systems. Not to belittle these because they are very important. However, reviewing the quality assurance paperwork of what is on the ship completely verifies the design is in accordance with design standards, drawings, and calculations.

ATLANTIS Certification

In order to satisfy the duel objectives of ensuring safe submersible handling and following the Department of Defense philosophy of using commercial standards wherever possible, the certification of the *Alvin* handling system on ATLANTIS will follow a hybrid approach. The Navy will remain the certifying authority for the handling system, but will accept Appendix D of the ABS rules for Building and Classing Underwater Vehicles, Systems, and Hyperbolic Facilities, 1990.

The A-frame stools and below deck supporting structure will be designed and constructed by the shipyard to ABS requirements. The shipyard will provide required drawings and calculations to ABS as if they were performing the actual certification. In lieu of a certification document, ABS will provide the Navy with a statement of fact that the installation meets ABS requirements. In addition the U.S. Navy certification load testing requirements, which are slightly in excess of ABS requirements , were imposed on the shipbuilder. The advantage to this approach was that the Navy safe submersible handling practices were maintained while retaining the commercial acquisition philosophy for AGORs .

Conclusion

In the decades to come, researching the oceans will increasingly require studies to be carried out on both local and global scales. Supporting this research will require oceanographic ships to be capable of supporting a variety of science missions simultaneously. ATLANTIS will be able to support the complete range of manned and unmanned deep submergence WHOI assets, including the ALVIN, MEDEA-JASON dual vehicle ROV system and the new AUTONOMOUS BENTHIC EXPLORER (ABE), a truly futuristic autonomous underwater vehicle capable of cruising unattended for weeks while gathering data. In addition, and most importantly, ATLANTIS can also provide a host of the more traditional operating characteristics so that this platform can serve in the complete range of ocean research. The innovative and versatile features incorporated into her design will carry ALVIN,

and any successor submersible, well into the 21st century. Modifying a new ship during construction, without impacting the delivery date or losing the ship's original mission capabilities, was a tremendous challenge. The Navy's flexibility in adapting the rigorous submarine handling certification requirements to commercial acquisition philosophy reduced potential costs and supported the ambitious schedule.

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The Authors

Daniel E. Rolland *was born in Crescent City, California in 1964. He graduated from high school in Waterford, Connecticut in 1981. He received his Bachelor of Science degree in Naval Architecture and Marine Engineering from Webb Institute of Naval Architecture in 1985. He is a licensed commercial pilot and flight instructor.*

At present he is Section Manager of Oceanographic and Survey Ships at John J. McMullen Associates, where he has worked since graduation from college. He currently provides engineering support for the AGOR 24, T-AGS 60, and T-AGS 63 ship programs. Previously, he provided support during the detail design and construction of the AGOR 23 and T-AGS 51/52 ships. This support included a period spent on site in the shipyard during final construction, trials, and delivery. He also provided support in the hull form and hydrodynamic areas of the T-AGS 45 contract design.

Steven L. Hannuksela *was born in Seattle, Washington in 1952. He has an Associate of Applied Science degree in Diving Technology from Highline Community College in Midway, Washington, and a Bachelor of Science degree in Mechanical Engineering from the University of Wisconsin - Madison. He wrote the section on Seaborne Transportation and Handling Systems, Section 2.2 of Chapter VII, of Submersible Vehicle Systems Design; and co-authored the Plans and Procedures section of the International Safety Standard Guidelines for the Operation of Tourist Submersibles; both published by SNAME.*

Mr. Hannuksela served four years in the Navy as a Radioman, and spent two years on a salvage ship. Before attending college, he worked as a seaman on the NOAA Ships DISCOVERER and FAIRWEATHER. After college, he was an engineer at MAR, Inc. where he developed the conceptual design of a launch and recovery system for a next generation Deep Submergence Vehicle. He is currently responsible for the technical aspects of Deep Submergence System and diver handling systems, and is Branch Head of the Closures, Outfitting, and Submersibles Branch at NAVSEA.

Thomas A. Demas *was born in Monterey, California in 1959. He has a Bachelor of Science in Civil Engineering from Old Dominion University and a Master's in Business Administration from Averett College. He is a graduate from the NAVSEA Commander's Development Program and the Defense Systems Management College. At present, he is the Assistant Project Manager for the AGOR 24, 25, and NOAA AGOR ship construction program.*

Mr. Demas served as a OPM Legis Fellow with Congressman John Spratt and a member of Mrs. Coleen Preston, DUSD(AR) procurement

process reform process action team. Prior positions include OPNAV Fleet Modernization Program action officer, CINCPACFLT maintenance officer, ASN(RD&A) Director of Maintenance and Modernization, NAVSEA 56W14 Branch Head of Closures & Outfitting group, and PMS314 project manager for DD963 Class destroyers. Before working at NAVSEA, Mr. Demas worked for TRACOR and C-CUBED Corporation.

THE SC-21 PROGRAM - WHAT WE ARE DOING RIGHT!

L. James Heller
21st Century Surface Combatant
SEA 03D3/PMS 400R1
Naval Sea Systems Command

Approved for public release. Distribution unlimited.

The views expressed herein are the personal opinions of the author and are not necessarily the official views of the Department of Defense or the Naval Sea Systems Command. They do reflect what is being practiced on the SC-21 project.

Abstract

The SC-21 is the next major surface combatant ship acquisition effort for the 21st century. Many things have changed since the DDG-51 program and there have been numerous initiatives to reduce acquisition time, cost, and improve design quality. SC-21 is committed to implementing these improvements to the maximum extent possible. This paper, developed by the program's deputy, definitively states what is being planned for the SC-21 program and what is actually being implemented now at the design site. The focus is on the Design Acquisition and Construction (DAC) TQM effort and subsequent process action teams in which the author was a participant. It will also address acquisition reform initiatives that are being addressed in SEA 91, PMS 400, and SEA 03, as well as other areas of special interest to the Command and audience.

List of Figures

Notations/Definitions/Abbreviations

APAS	Civilian Employee Evaluation System
ARPA	Advanced Research Projects Agency
ATC	Affordability Through Commonality
CADD	Computer Graphics System
CALS	Computer Aided Logistics System
CDRLs	Contract Data Requirements List
COQ	Characteristics of Quality
COTS	Commercial Off-the-Shelf
CVX	Next Generation Aircraft Carrier
DAB	Defense Acquisition Board
DAC	Design Acquisition and Construction
GENSPECS	General Specifications for Shipbuilding
GFI	Government Furnished Information
HAYSTACK	Equipment Procurement System
HEDRS	HM&E Equipment Data Research System
ILS	Integrated Logistics Support
INSURV	Board of Inspection and Survey
IPT	Integrated Process Team
ISEA	In-service Engineering Agent
KSCIP	Key Ship Technologies SCIP
LCC	Life Cycle Cost
M&S	Modeling and Simulation
MAPP	Master Acquisition Plan Program
MIL-SPECs	Military Specification
NAVSEA	Naval Sea Systems Command
NAVSEC	Naval Sea Engineering Center
ONR	Office of Naval Research
OPNAV	Chief of Naval Operations Staff
ORD	Operational Requirements Documents
PARTSMASTER	Equipment procurement tool
POA&M	Plan of Operation , Approach, and Milestones
QMB	Quality Management Board
RMA	Reliability, Maintainability, Availability
ROM	Rough Order of Magnitude
SC-21	21st Century Surface Combatant
SCIB	Ship Characteristics Improvement Board
SCIP	Ship Characteristics Improvement Panel
SE	System Engineer
SUPSHIP	Supervisor of Shipbuilding
TL	Functional Task Leader
TQM	Total Quality Management
TSEG	Total Ship Engineering Workgroup
TSSE	Total Ship Systems Engineering

Introduction

Significant corporate investment is being devoted to improving the NAVSEA headquarters operation and how business is conducted. Recent initiatives by the Commander include the Strategic Planning initiative TQM efforts to define NAVSEA's role and improve the process of developing ship designs. This paper will concentrate on selected studies and how they are being implemented on the SC-21 project. The SC-21 project is not unique in this area. Much of what we are doing has already been applied by other ongoing design projects. The aircraft carriers, submarines, amphibious ships, sealift ships, and destroyers all have successful design sites in operation and are implementing many of the same improvements. Undoubtedly, there are other significant lesson learned efforts that should be addressed in the SC-21 management planning. Through this effort I hope to learn from the readers what we should also be considering to improve our efforts.

SC-21 background: The SC-21 is currently in the phase 0 (Concept Exploration). The project has established a collocated design site with approximately 30 people cross-assigned to work in our spaces.

The early program initiative was conceived at OPNAV and the Mission Need Statement that resulted provides a very broad challenge for the SC-21. The ability to succeed in major improvement initiatives starts from the onset of a project. Schedule, tasking, and funding directly control the projects ability to achieve desired change. It also requires corporate commitment, in the form of people, facilities, and a certain amount of trust (empowerment) to the early project leaders.

The SC-21 was extremely fortunate to benefit from the early initiatives of the Gang of Two (RADM Huchting and RADM Firebaugh). They started the "tracks" to a different direction for ship design and have been the conductors through the early planning. Note: the Gang now has grown to seven, with all major system commands/PEOs represented. This group has assumed an advisory capacity for the SC-21 and will no doubt be instrumental in our ability to continue towards a different future.

Our schedule structure and acquisition approach are still under development. What I will be presenting is <u>all subject to change.</u> That is a frequent statement and the Command's commitment to the Malcolm Baldrige approach to efficient operation. This paper and my presentation will address what the SC-21 Program Office is doing now to integrate the completed

within all project offices. "It isn't over till it's under contract, and then it's just beginning". The schedule dates will be event driven, but Phase 0 has a total of 2 1/2 years allocated to develop the first definition of what the SC-21 will be. As the SC-21 Deputy Program Manager, my primary responsibility is to effectively use that time to create an organizational structure and acquisition process to facilitate the revolutionary design that our team envisions.

DESIGN TQM HISTORY: Many studies were performed through the years since NAVSEC/NAVSEA were established. Surprisingly, many of the old studies are being requested - change may not always lead to something new and untried. Planning for the next design projects should include a cursory review of these efforts for current value in today's acquisition environment. See Figure 1.

Time is critical to projects and this forum. Therefore, I will only concentrate on recent design process efforts.

The first study that I would like to benchmark is the **TOTAL SHIP ENGINEERING (TSEG)** - Art Spero (SEA 92R) - effort reported out in April 1989. The group was chartered to define Total Ship Engineering, identify problem areas, deal with engineering execution, refine organizational interfaces, and institutionalize itself. This study received limited distribution, but it does provide valuable insight that is relevant today.

1. **TOTAL SHIP ENGINEERING (TSE)** - It identified major factors in the TSE approach that included;
- Dialog with sponsors during the establishment of design requirements/constraints and ensure that the requirements and constraints are clearly stated.
- Select appropriate ship elements taking advantage of existing and emergent technologies and, when required to develop satisfactory design solutions, define future interface requirements and influence R&D goals and schedules.
- Combine the ship elements into configurations that are postulated to meet the requirements and constraints.

- Analyze/iterate the postulated configurations to determine which alternatives produce a design which is effective, efficient and meets stated requirements and constraints.

Road blocks:
- Combat systems and HM&E systems are not fully integrated.
- R&D Master Plan not influenced by ship design.
- Actual capabilities are often less than predicted.
- Ship designs do not contain appropriate existing and emerging technologies.
- Rationale for past decisions is lost.
- Some poor quality work gets released.
- Management doesn't take risks.
- Some ship designs render elements incompatible.
- Ship and equipment designs are not properly balanced

SC-21 Implementation: We have established a team of SC-21 system engineers and technologists to work together addressing the above issues. Andy Summers (SEA 03D3), Vince Juric (PMS 400B), and Dick Wyvill (SEA 03R) are leading the efforts to bring more technology to work on new ship designs. We are working very hard to link up with ONR, ARPA, Navy labs, and industry to bring out the new technologies/systems and see what they do on ship concepts. Team 8D - CAPT Preisel (SEA 03R) lead, is working many of the corporate issues in this area and is sharing his work and recommendations with us. The Key Ship Technologies Ship Characteristics Board (KSCIP), a recent N-86 initiative spearheaded by CDR Mike Bosworth (N 863) and LCDR Mike Good (PMS 400R), promises great opportunity to better identify and transition critical ship design technologies. Risk taking is a difficult area. Andy Summers has been pursuing the need for a "demonstrator ship" and may offer system engineers and technologists a platform to play directly with the fleet.

SC-21 GRADE: B+ TREND: UP

Next, following in the same chronological order that they were developed, I will address DAC recommendations, and the status of their accomplishment.

The **DESIGN ACQUISITION AND CONSTRUCTION (DAC)** - RADM Horne, Bob Keane, Kit Ryan, Karen Christesen - was a major TQL effort undertaken in 1991 to:

> *IDENTIFY THE CRITICAL ACTIONS NECESSARY TO IMPROVE THE QUALITY OF FUTURE SHIP DESIGN (I.E. MEETING CUSTOMER'S REQUIREMENTS) TO REDUCE SHIP CONSTRUCTION COSTS, LIFE CYCLE COSTS, AND TO REDUCE THE TIME REQUIRED FROM ESTABLISHMENT OF REQUIREMENTS TO DELIVERY OF THE LEAD SHIP.*

Eight teams were commissioned and leaders with broad coverage from NAVSEA were assigned. The total effort lasted approximately one year and the findings were briefed to the Command's QMB and industry at a two-day structured session in Richmond.

Thirteen major recommendations were presented at completion. These included:

2. **CUSTOMER FOCUS & UNDERSTANDING** - A mandatory precept of all TQM-oriented programs is that the customer must become the focus of all work. We have difficulty in identifying a sole customer to be attentive to; a nominal list of customers we developed during the study has at least twenty different organizations shown, including Congress. But this problem is not unique to us and does not relieve us of following our first principle.

Road blocks:
- Have N-8 sign all Operational Requirements Documents (ORDs).
- Develop an effective training program in OPNAV on the total ship design and acquisition process.
- Establish a permanent, rotational billet on the SCIB permanent staff for combat systems.
- Establish a single NAVSEA POC on all SCIP matters.
- Develop a document which describes the "hidden requirements which are cost/size drivers, and are set by organizations outside N-86, and assess the ship impact of these requirements.
- Establish pre-milestone 0 SCIB working group.
- Institutionalize a pre-milestone 0 requirement setting process.
- Strengthen the SPAWAR participation on the SCIB working groups.
- Assign a fleet representative with recent operational experience on similar mission ships to the design team.

- Designate a point of contact from INSURV to support the design team during the project development.
- Identify the customers and establish paths of communication.
- Achieve consistency between design standards, practices, policies, and specification and fleet expectations and experience.
- Develop and implement training programs for NAVSEA personnel in:
    - SCIB and DAB process
    - Impact of requirements on cost
    - Systems engineering
    - Modern shipbuilding methods and producibility.
    - Fleet operations and operational logistics.

SC-21 implementation: An SC-21 team member, LCDR Mike Good (PMS 400R) - our requirements engineer, is assigned to the SC-21 OPNAV sponsor. He is working the critical systems SCIP (KSCIP). SPAWAR is represented on newly forming KSCIP Steering Committee (RADM Combs). The SC-21 approach has been briefed to INSURV but no POC is assigned. SC-21 requirements development effort will include meetings with the fleet in a QFD based process. SE training is ad hoc - relying mostly on outside sources.

SC-21 GRADE: B TREND: UP

3. **LONG RANGE PLANNING** - By the time a specific ship acquisition commences, the range of options for many of the key elements of the ship is already limited. Typically, most combat system equipment must be near completion in order to be considered. These equipment are developed in a similar, and even more lengthy, acquisition process that typically lasts 15 years. Thus, if it's not off the shelf by milestone 0, it usually misses the time window for the ship design acquisition and construction. The need to be "prepared" for acquisition requires up-front planning for both shipboard systems and other technologies, such as new hull forms, so that the most appropriate set of options are available for consideration when needed.

Road blocks:
- Develop an integrated approach to total ship engineering.
- Expand NAVSEA's involvement in the budget cycle. (R&D and SCN)
- Establish a NAVSEA POC for coordination with SPAWAR.
- Establish a dedicated 6.3 RDT&E line for systems development - long range planning.
- Establish a process to prioritize R&D investments to effect maximum benefit for the Navy.
- Establish land based facility for demonstrating prototype system performance, developing and evaluating system/component improvements and creating system modules ready for shipboard installation.

SC-21 implementation: The SC-21 total ship system engineering approach is identifying the major equipment needs for the lead ship as well as follow ships. The "honey comb" slide that was presented in the SC-21 POM 98 submittal addresses the project required funding as well as the major system budget requirements. We have a team of technologists, headed by Dick Wyvill, collocated at the site working the early technology needs with ARPA, ONR, and Industry. The SC-21 will also possess the flexibility to adopt new systems efficiently and economically.

SC-21 GRADE: A TREND: UP

4. **CONCURRENT SHIP AND SYSTEMS DEVELOPMENT** - The lengthy design acquisition and construction cycle for new ship classes often precludes having the latest equipment available for installation because selections are locked-in very early on. This often results in the installation of obsolete equipment which must be replaced immediately upon ship delivery. More parallel development of the ship and key equipment can occur with innovative techniques, such as Design Budgeting to reserve space, weight, electric power, etc. to install equipment late in construction. Complementary procedures such as Just-In-Time GFE deliveries and "turnkey" systems installation can greatly increase the ability of accepting the latest equipment prior to ship delivery. This capability is not optional for the Navy - we must have the most capable fighting ships when we go to sea.

Road blocks:
- Develop a NAVSEA instruction which establishes policy during ship design regarding concurrent development of main sub-systems critical to ships mission.

- Utilize design or system budgeting and standard interfaces for integrating state-of-the-art systems/equipment into ship design/construction.

SC-21 implementation: The SC-21 MNS requires extensive use of modularity and dictates developmental systems to meet the requirements at affordable costs. The SC-21 approach reflects this in the acquisition and the early systems engineering planning. The envisioned Open System Architecture, by definition, will facilitate efficient upgrade through the ship's service life. We are working closely with Jeff Hough's (SEA 03R) ATC people to achieve modularity and commonality to support a "family of ships".

SC-21 GRADE: A TREND: UP

5. AVAILABILITY OF APPROPRIATE RESOURCES - There is overwhelming evidence that people's productivity and effectiveness are dependent on the resources provided by management. Many of these Strategic Principles simply cannot be achieved without properly trained people, adequate facilities, computers, software tools, design techniques, information data sources, and similar supporting resources. These distinguishing characteristics of resources are not consumed during specific ship acquisitions; they are the infrastructure of the organization.

Road blocks:
- Develop and improve design methods for ship system, ship baselines and mission effectiveness throughout all stages of design.
- Improve early stage ROM cost estimation inputs and techniques.
- Establish a plan to provide required design talent to support OPNAV based on maintaining in-house design skill capability.
- Provide adequate project management tools.
- Establish team to explore ways to make ship design work more attractive, desirable, and rewarding by removing "roadblocks" (de-motivators).
- Establish a study team to study ways to better utilize the technical and /or management support contractors to assist/augment NAVSEA designers.
- Prepare a source directory of feedback information.
- Develop feedback databases and procedures to maintain them.

SC-21 implementation: The SC-21 team comprises the necessary skills from the System Commands to effectively lead the design effort. What is required is the involvement of system engineers in the newly commissioned IPTs that the SC-21 will use extensively to achieve the total ship systems engineering. There is an education required of the current engineers to achieve the TSSE objectives.

SC-21 GRADE: B TREND: UP

6. NAVY/SHIPBUILDER/SUPPLIER PARTNERSHIP - The litigious nature of current government/industry interactions has created an "arms length" relationship between the Navy and its primary shipbuilders and suppliers. Fixed price, highly competitive contracts do not serve to save money in the long run, but rather make the payment of legitimate costs for ships equipment's and construction more cumbersome to accomplish.

SC-21 implementation: SC-21 is planning effective, timely industry involvement. We are hampered by funding and contractual boundaries. Dialog has started with Navy/Industry workshops and briefings to professional organizations. The SC-21 has started a home-page on the web for wide dissemination of SC-21 information. The acquisition strategies planned will make significant inroads in this area.

SC-21 GRADE: B TREND: UP

7. **TOTAL SHIP ENGINEERING** - The principle of working as a team to optimize the whole ship development. It includes: **teaming** - teams that are physically collocated and empowered to make decisions are better able to reach difficult compromises that are a fact of life with all designs. Combat system engineers, naval architects, marine engineers, shipyard production planners, program management, cost analysts, logisticians, and many others can be most effective when organized into a project team; **integration** - is meant the making of design decisions that are in the best interest of the overall ship design and acquisition goals and constraints; **concurrent design** - the simultaneous design of the product and the process by which it will be constructed. Achieving concurrent design requires that the shipbuilder be selected early in the design and become an integral member of the design team; and **life cycle cost** - cost assessments must be made for each major design

decision. LCC is the major driver in the costs of ownership.

Road blocks:
- Plan for early participation by industry in the ship acquisition process as a member of collocated Navy design teams.
- Collocate design teams and link outsiders electronically.
- Empower design team with technical decision-making authority.
- Create dedicated, multi-function design teams of trained, experienced, qualified systems engineers.
- Improve the ship specification by starting it earlier (during Preliminary Design (PD). Improve the quality of the Gen Spec.
- Designate the Combat System Engineer and Mission System Engineers at milestone 0.
- Logistics must be designed concurrently with the ship design at the design site.
- NAVSEA should be able to identify all equipment by brand name. Use "or equal" clause to meet contractual/legal requirements.
- Institute risk management into ship acquisition programs.
- Develop tools to make decisions based on life cycle implications. Expand and formalize steps in the design process to encompass modernization efforts.

SC-21 implementation: The SC-21 team is currently composed of program management and systems engineers. All technical areas are represented through principal system engineers that are physically located at the site. NSWC / NUWC / SPAWAR engineers are working together with NAVSEA engineers to accomplish the TSSE planned for this project.

SC-21 GRADE: A TREND: UP

8. **"BEST KNOWN METHOD" BUILD STRATEGY** - Shipbuilding practices lag behind in the US. The use of product-oriented construction techniques, such as zone pre-outfitting, can produce significant time, cost, and quality improvements.

Road blocks:
- Develop and institutionalize a formal process within SEA 03, including the necessary funding for reviewing and correcting ship construction/technical specifications which do not add value to the ship.
- Pro-actively support ongoing efforts to improve the capability of US shipyards to compete in the international commercial shipbuilding market.
- Commit to product oriented ship design acquisition and construction.
- Develop, maintain, organize and control a library of flexible "standard" design modules that can be used across platforms.

SC-21 implementation: Work has not started effectively in this area. We have a link with the ATC program, but have not pursued to any greater extent. Our teaming plan with industry should greatly facilitate concurrent engineering in phase I.

SC-21 GRADE: C TREND: FLAT

9. **DATA CONTINUITY THROUGHOUT THE SHIP LIFE CYCLE** - Technical information about the ship is needed throughout its life, from the beginning of design, through construction, and for the 30 years typical of service life. Currently, data of all types is maintained in a multitude of diverse forms and places, with redundancy, incompatibility, inconsistency and inaccessibility being a common occurrence among the sources.

Road blocks:
- Digital design information should include requirements, design definition, design evaluation, and configuration management.

SC-21 implementation: This is a key concern and we are lagging where I would like to be. We are working with SEA 04 on the adoption of their MAPP program for acquisition documentation management. M&S is beginning to address this area in the "smart" product models that include much of the data sharing requirements needed to support the total program requirements. Currently we have started a project library and a technology master listing. We are actively pursuing a seamless management tool to cover all program data needs.

SC-21 GRADE: C TREND: UP

10. **CONTINUITY OF THE SHIP DEVELOPMENT PROCESS** - Currently there are numerous discontinuities in the development of a navy ship: stoppages for review/approval cycles between design stages can last months; contracting for the lead ship

takes about a year; navy oversight of construction is done by different people in a different organization than the initial design work.

Road blocks:
- Design effort should be continuous from MS I to MS II or end of Contract Design (CD).
- Compress the number of reviews.
- Do selected detail design tasks at NAVSEA which are natural extensions of already developed design products, and provide as GFI to the shipbuilders.
- Provide existing or already developed contract design data to shipbuilder as GFI.
- NAVSEA design cadre should relocate to detail design acquisition and construction site as on-scene design representatives supporting the project manager's representative.
- SUPSHIP must be in force at detail design site and come to NAVSEA for design familiarization.
- Establish a study team to determine ways to improve contracting procedures to avoid lag time during design development.

SC-21 implementation: Our acquisition strategy will facilitate teaming with industry through phase I of the project. We are addressing the required competition points in the process coupled with the desire to maintain a continuous workforce through the acquisition period.

SC-21 GRADE: B TREND: UP

11. **INSTITUTIONALIZING PROCESS IMPROVEMENTS** - Total Quality Leadership, the Navy's version of TQM, requires that the senior management lead the organization through continuous process improvement.

Road blocks:
- A method should be instituted to frequently, but informally, evaluate the design process, the level of quality it provides and implement improvements to correct deficiencies.

SC-21 implementation: This paper represents a start at communicating the operations of the SC-21. We also conduct quarterly program reviews for PMS 400. The Gang of Seven has assumed an advisory role and will be involved to a greater degree in assessing our progress. There are no cross-program assessments being conducted by the Command that I am aware of.

SC-21 GRADE: B TREND: FLAT

12. **FACTS-BASED MANAGEMENT** - The key function of management is often described as the "making of decisions in the absence of complete information". The whole organization must measure, record, analyze, and present the facts when decisions are being made.

Road blocks:
- Develop measures of quality to improve the quality of the engineering product.

SC-21 implementation: I hope to institute checklists for assessing the quality of all products that will be used on the project. A strong technical code involvement from the engineering directorate is needed for the SC-21 and we will be competing for limited resources with other Command needs.

SC-21 GRADE: C TREND: FLAT

13. **PROCESS TRAINING** - Virtually all people involved in ship acquisition "see" the process differently, leading to much confusion and differing priorities. It is not enough for only the Program Manger to know (or think they know) the process, the engineers and others must also have some level of understanding.

SC-21 implementation: Greater work needs to be done in this area. We are pursuing a master schedule that will hopefully communicate the needs among the SC-21 system engineers. SEA 03D has an excellent overview presentation on the ship design process to support this. Scheduling has precluded getting target OPNAV sponsors to these sessions. This is a critical area that needs work.

SC-21 GRADE: C TREND: FLAT

14. **PROCESS TECHNOLOGY INVESTMENT** - More sophisticated technology must be actively pursued. There is every likelihood that computer modeling of the ship DAC process is possible. Such a tool could provided managers and designers alike with a powerful means of evaluating our process and proposed changes., Such a process technology could give the whole organization the tools it needs to continually improve.

SC-21 implementation: We are adopting PS 6 for scheduling and the MAPP for acquisition work. I do not know of any other work in this area that could be applied.

SC-21 GRADE: C TREND: FLAT

15. **THE SURFACE SHIP SPECIFICATION PROCESS PAT** - was the next definitive TQM effort to address specific DAC recommendations. A small team, led by Dave Byers, was chartered and the output of that effort was a list of recommendations and a Process Guide to be used for specification development. The Process Guide establishes an organized, timely approach to developing a new ship specification. It also clearly identifies the responsibilities of each major member of a design team, a time line to follow for development and certification, and rules of conduct for the reading sessions.
The recommendations of the PAT included:

Road blocks:
- * Management should document what is expected by all participants of the ship specification reading session.
- * Supervisors should review the TL's spec before the reading session.
- * APAS critical objectives should include reading session performance, an MVP should be awarded.
- * Division and subgroup heads should attend.
- Feedback should be provided on the quality of the spec submitted.
- * Training should be provided prior to the reading session.
- * Gen Specs should be maintained.

SC-21 implementation: The SC-21 has conducted several planning meetings for the development of the specification and have a working POA&M.. Our pace is limited by the lack of funding in this fiscal year for spec development, however, we are planning the first reading session in the Fall of 1996. Rick Bergner (SEA 03D3) is working with SEA 03R and our team to lay out the format for a performance-based, total ship, "A" level of definition, specification. Potential industry areas will be invited to participate in this phase 0 effort. The asterisked objectives are incorporated in the Spec Process guide which the SC-21 will tailor and distribute. We do have agreements with supervisors to evaluate all team members on their performance and provide formal input to supervisors for APAS purposes. We also will look closely at the AOE-10 documentation and the lessons from the NAS and LPD 17 projects as we proceed.

SC-21 GRADE: B TREND: UP

THE COLLOCATED DESIGN SITE PAT - next reported it's findings. I chaired this PAT that was composed of members with design team experience and broad points of view. The challenge was to balance the need for collocation to maximize the quality of the design product with the responsibilities that the system engineer's retained with their functional code. The formal report was presented to the QMB and endorsed for implementation. The CVN, DDG, NAS, LPD, and SEALIFT managers have all used the checklist (I was their supervisor) and have achieved remarkable successes. The major areas of consideration include:

16. **THE FACILITY MUST SUPPORT THE ENGINEERING.**
- It should have a space commitment sufficient to support the duration of the design.
- It **must** be within a 15 minute walk of the functional code offices.
- It should have the level of security and size to facilitate operations.

SC-21 SCORE: We have recently expanded into the South end of NC-2 sixth floor. Sufficient space is available for the design work envisioned. We are also adjacent to the NAS, CVX, and ARSENAL ship designers which facilitates info sharing.

GRADE: A - 92% TREND: UP

Note: Numerical grades are assigned since a checklist is available to score this area.

17. **THE EQUIPMENT MUST SUPPORT THE ENGINEERING.**
- There must be CADD workstations, drawing boards, "smart" conference rooms, office equipment, software, personal computers, staff, technical and programmatic data, and quality of life attributes to attract and support efficient operations.

SC-21 SCORE: NAVSEA could benefit from a corporate investment in this area. Project R&D resources are slight and inappropriate for these accounts. The SC-21 has made due and are functional, but have an OM&N shortfall of $70,000 from where I want to be.

SC-21 GRADE: C - 73% TREND: FLAT

Note: Numerical grades are assigned since a checklist is available to score this area.

18. **THE PERSONNEL ASSIGNED MUST SUPPORT THE ENGINEERING.**
- Total ship systems engineering requires more diverse skills earlier in the process. The site must be composed of design leaders in all significant technical and programmatic areas in order to integrate and balance the final product.

SC-21 SCORE: The collocated team is truly a success story. The breadth of skills and experience assigned to the project was not available to the DDG designers. We do have a workload issue with IPT support from NAVSEA. We do lack operator involvement and that is a top priority for our planned briefings to SURFLANT/SURPAC this quarter.

SC-21 GRADE: B - 80% TREND: UP

Note: Numerical grades are assigned since a checklist is available to score this area.

The final TQM study that I would like to address in the **CHARACTERISTICS OF QUALITY** effort lead by Judy Trull (SEA 03W). This effort addressed the ways of improving the quality of the Contract Design package and utilized a wide-based survey to assemble the views of 216 respondents to support the 116 quality recommendations.

19. **BUILD STRATEGY.**
- A standard build strategy should be established for each design stage.
- Standardized construction details must not preclude shipbuilder competition.
- Each shipbuilder can build best by their own standards, Navy should facilitate the production process.
- Construction detail should be simplified wherever possible.

SC-21 APPROACH: Covered above in DAC #8.

20. **CONTRACT DATA REQUIREMENTS LIST (CDRLs).**
- Establish training or guidance procedures for CDRL definition and development.
- Gain tech code input as the Program Manager tailors the CDRLs.
- Develop a checklist to ensure all CDRLs are considered during the early contract design stage.
- Ensure CDRLs are in the approved CALS format.

SC-21 APPROACH: Discussions are headed towards electronic CDRLs modeled after the success of the NAS. The Statement of Work will address in detail what is required of the industry. Teaming should eliminate many of the CDRLs.

SC-21 GRADE: B TREND: UP

21. **CORROSION CONTROL.**
- Develop and use checklists to ensure proper corrosion protection.

SC-21 APPROACH: Covered by DAC # 12 above

22. **FACILITIES MAINTENANCE AND FATIGUE LIFE ISSUES.**
- Develop checklists to ensure that facilities maintenance requirements are considered. "reduce maintenance, reduce people, reduce costs".
- Define how fatigue life considerations in equipment will affect the primary and secondary structure and COTS equipment selection.

SC-21 APPROACH: Covered by DAC # 12 above

23. **DIGITAL DATA ISSUES.**
- A means for digital transfer of CAD products is needed.
- Use electronic data deliverables.
- Provide digital data to the shipbuilders and develop methods to resolve difference between paper and digital products.
- A 3-D product model should be the "document".

- Establish a standardized distribution method for reviewing specifications and drawings utilizing digital networks.

SC-21 APPROACH: We will have a full-time CADD engineer, Rick Zebrowski (SEA 03R), assigned to the project to work these issues and achieve these objectives.

SC-21 GRADE: B TREND: UP

24. GENERAL ENVIRONMENTAL ISSUES.
- Identify environmental early.
- Develop procedures to deal with unique state issues.
- Procedures should be established to deal with future environmental requirements as easily as possible.
- The Navy places too many environmental requirements on shipbuilder installed items, without ensuring they can actually be met.
- Consider a higher level review of "outside agency requirements".

SC-21 APPROACH: We have a environmental engineer, Lyn Carroll (PMS 400D), assigned to the project to work these issues and represent the SC-21 in the formulation of environmental policies.

SC-21 GRADE: A TREND: UP

25. GENSPEC ISSUES.
- Genspecs are typically out of date and therefore unreliable.
- Justification of deviations from GENSPECS will be a large task because there will be too many to make it worthwhile.
- Since INSURV uses GENSPECS, then their inputs should be reviewed for GENSPECS changes.
- Develop a procedure to ensure that only applicable GENSPECS requirements are used.

SC-21 APPROACH: The SC-21 is committed to a performance based "A" level specification at MS I. GENSPECS will not be ignored, but it will not be invoked. Rick Bergner (SEA03D3) and SEA 03R are working this area with us.

SC-21 GRADE: A TREND: UP

26. INTEGRATED LOGISTICS SUPPORT PLAN ISSUES.
- ILSP should be consistent with spec requirements.
- ILSP is never provided to the functional engineers, until <u>after</u> the fact.
- ILSP is inconsistent with COTS equipment and 7 years obsolete.
- ILSP is starting to drive design at technical and acquisition cost expense.
- The Navy should **never** propose or accept a logistics plan which is not supportable or achievable.

SC-21 APPROACH: We have an ILS manager, Tim Phillips (PMS 400F), assigned and he is leading a ILS IPT. His vision reflects the "system of systems" approach and will be closely aligned with industry in the future life cycle phases.

SC-21 GRADE: A TREND: UP

27. GENERAL ILS ISSUES.
- Full integration of the ILS product should be required.
- ILS top level requirements should be specified within section 080.
- ILS sections should be written with knowledge of the total contract design package.
- Many ILS requirements are overlooked if they are not tied to a equipment/system spec section.

SC-21 APPROACH: See item #26 above.

28. CONFIGURATION MANAGEMENT ISSUES.
- Configurations that are held by NAVSEA must be to the same level as that invoked on the contractor.
- Define who's responsible for configuration management - shipbuilder or Navy.

SC-21 APPROACH: Our statement of work to industry will clearly identify each party's roles and responsibilities. CADD and the Smart Product Model will greatly aid the configuration control area.

SC-21 GRADE: B TREND: UP

29. SERVICE LIFE ISSUES.
- Service life allowance must be tailored to specific design.
- Equipment selected from the HM&E Equipment Data Research System (HEDRS) is dated. The

HAYSTACK and PARTS MASTER are far more effective.
- Modular equipment should be listed in HEDRS.
- Incentives should be given for using HEDRS listed equipment.

SC-21 APPROACH: Life Cycle Cost is a principal driver in the project. We are working the service life issues and the role of industry after delivery. We are working with LPD-17 to assess possible changes in this area.

SC-21 GRADE: B TREND: UP

30. **TRAINING ISSUES.**
- SEA 04MP should be involved with the project to address training issues.
- Early problems with new equipment could be avoided or diagnosed earlier with training.

SC-21 APPROACH: Need to start working into the ILS IPT.

SC-21 GRADE: C TREND: UP

31. **RM&A ISSUES.**
- The real Ao can only be determined by time in service.
- Reliability itself, and not assessment, must be performed.
- RM&A must be addressed early in design for the designers to reflect the requirements in their equipment/systems.
- The Total System Availability (Ao) in the ORD needs to be defined for the working level engineer so they know how their work impacts reliability.
- Ensure design is consistent with the maintenance philosophy or vice versa.
- Develop reliability standards.
- Ensure reliability performed means tested.

SC-21 APPROACH: Tasking for RMA was issued last year. We have Bill Lohmar (SEA 03D7) and Jim Montgomery (PMS 400B) assigned as co-leaders of a bi-weekly RMA working group. They will address the above issues and integrate with SE's through these planned efforts.

SC-21 GRADE: B TREND: UP

32. **FIELD ACTIVITY INVOLVEMENT.**
- Involve field activity and ISEAs in the early design stages.
- Ensure that the field activity and ISEA lessons learned from prior shipbuilding contracts are adjudicated.

SC-21 APPROACH: NSWC is a strength. We have full time engineers from Dalhgren, Carderock, NUWC, Crane, and close links to NWAD and NRAD.

SC-21 GRADE: A TREND: UP

33. **GENERAL PROGRAM MANAGEMENT ISSUES.**
- Implement a formal program to identify and implement lessons learned from other programs.
- Establish a design budget approach early.
- Provide shipbuilder additional time to prior their bids.
- Determine who provides legal counsel to the design.
- Capability must be prioritized over costs and other factors consistent with ship's mission.
- Equipment selections must be compared on the cost of ownership perspective.
- Lead time of major equipment should be established early and agreed upon by the concerned parties.
- Cost of installation must be included in all trade-off studies.
- SEA 00L and SEA 002 should be more proactive in the projects.
- Disseminate guidance to the functional engineers in the early stages of the design process so that they are aware of and understand all requirements.
- Ship mission is of paramount importance, since cost is a driving force, areas such as energy conservation should fall below "ship mission".
- The DAC findings should be disseminated to the project members.
- A quality Assurance Manger should be assigned to the project.
- The project should have a software acquisition management plan.
- Ensure that the latest certification requirements for systems and equipment are included in he applicable contract documents.
- Each project should tailor these recommendations and develop checklists.

SC-21 APPROACH: There is a lot of direction in the bullets above. I think we are working the right issues

and headed on the right approach. "Give me a "B" now and watch us".

SC-21 GRADE: B TREND: UP

34. AVAILABILITY OF CONTRACT DESIGN REFERENCE MATERIAL.
- Establish a reference library for each project.
- Define the level of detail for the contract package.
- Supplemental design data should be shared with the shipbuilder.

SC-21 APPROACH: Work in progress by small groups at this time. Will expand and clarify within next 6 months.

SC-21 GRADE: C TREND: UP

35. OPERATIONAL REQUIREMENTS DOCUMENT (ORD) ISSUES.
- The ORD must be consistent with the contract design package.
- Contract package must be changed to reflect updates to the ORD.
- Constraining requirements by cost to meet the ORD is a detriment to quality.

SC-21 APPROACH: Not yet started. We are developing a requirements tracing software to assist in this area and have a full-time requirements engineer assigned to the project.

SC-21 GRADE: C+ TREND: UP

36. RISK ASSESSMENT ISSUES.
- Performance risk affects quality. The Navy must ensure it has sufficient management resources to address these concern.
- Life cycle costs must be included in the risk equation.

SC-21 APPROACH: Working with DDG program for lessons learned. Dick Holmes is notionally assigned to be SC-21 risk manager, but not in force yet.

SC-21 GRADE: C+ TREND: FLAT

37. STREAMLINING, STANDARDIZATION & COMMERCIALIZATION ISSUES.
- Standardization must be defined for the project.
- Standard streamlining procedures should be used on all projects.
- All non-standard items should be listed with rationale.
- Continue the use of the class standard equipment.
- Navy owned packages should only be used if they pass the test of lower life cycle cost.
- The Navy should ensure that any future equipment or system development program that receives RDT&E funds results in a Navy owned design package which will allow the government to consistently reproduce those items.

SC-21 APPROACH: An area of concern. Working with CAPT Gauthier (PMS 317) and Choir - an after hours Program Managers skull session - to determine the "right track" for this area. The COQ hit a hot area!

SC-21 GRADE: C TREND: UP

38. COMMERCIALIZATION.
- Navy should budget up front for the added time and cost to include commercial equipment into the Navy system.
- The lack of schedule control should be considered with commercial items.
- Commercial specs may not add quality, nor reduce costs. The goal is to achieve military compatibility to existing industry infrastructure.
- The Navy should establish procedures and guidelines which allow Navy owned design packages and government standards to prevail whenever mission unique equipment and systems are required.
- Do not let military requirements creep into commercial specs.
- An enormous effort is required to validate each occurrence of MIL-SPECs in a package.
- How can the Navy ensure that the shipbuilder purchase reliable equipment.
- Shipbuilders should be protected from required equipment that have not been proven feasible.
- Off-the-shelf is a volatile term in combat system arena.
- Commonality and use of COTS are mutually exclusive.
- Develop incentives to industry for alternative solutions to military specs and standards.

SC-21 APPROACH: Starting with a performance spec and teaming with industry early in phase I should provide great improvements in this area. This will be a major topic of concern to the project to be watched closely. ILS IPT will be the lead.

SC-21 GRADE: B TREND: UP

39. **TESTING, TEMP, TRIALS.**
- All requirements for test should be included in the specs.
- The TEMP must be consistent with the specs.
- The TEMP should be flexible vice written "in stone".
- The TEMP should be developed to test what is written in he ORD, not the specs.
- A testing philosophy is needed. It should address early tests of concepts and frequent tests of operation.

SC-21 APPROACH: We have test engineer assigned, Jesse Terres (PMS 400D). He is starting an IPT to address these issues with the same goals.

SC-21 GRADE: B TREND: UP

SUMMARY

The above TQM findings represent a significant corporate investment and a wealth of documented "lessons learned" for all project managers. These documents are widely available and remain current to today's operating environment. Their findings should be heeded.

Additionally, I encourage the audience to participate in future PAT efforts like those listed above. This is where major change starts and your active involvement guarantees a "torch holder" to move the Command forward into the 21st century.

Finally, to all the future report editors - please keep it short. Project offices by nature are busy places with minimal time at the end of the day for strategic planning. Supporting data is critical to understanding, but viewgraphs and checklists are vital to execution. Also, be standing by as the advocate to help us already on the "train". Your help is essential to NAVSEA's success.

Summary of all assigned grades

1. B+	11. B	21. C	31. B
2. B	12. C	22. C	32. A
3. A	13. C	23. B	33. B
4. A	14. C	24. A	34. C
5. B	15. B	25. A	35. C+
6. B	16. A (92%)	26. A	36. C+
7. A	17. C (73%)	27. A	37. C
8. C	18. B (80%)	28. B	38. B
9. C.	19. C	29. B	39. B
10. B	20. C	30. C	

SC-21 OVERALL GRADE: B+
TREND: TBD

Acknowledgments

This paper was a true team effort, but special recognition is needed for Ms. Lisa Hubbard, my editor.

References

The reports referenced in this paper are available for review in the SEA 03D3 technical library managed by Mary Dieguez, SEA 03D3M.

Biography:

***L. James Heller** is a Division Director in the SEA 03 Ship Design Group. He is currently matrixed to the SC-21 program as the deputy Program Manager. Jim first joined NAVSEA in 1980 after five years active service in the Navy. He has completed the EIT program, DSMC Program Manager's course, GWU Engineering Administration master's program, and holds a professional engineer's license in naval architecture and marine engineering. He was a member of the Design acquisition and construction TQM effort, the specification reading session improvement pat, the collocated design site pat, and the characteristics of quality pat. He is a member of ASE, ASNE, Naval Institute, and the Surface Navy Association.*

Figure 1:

TABLE 1: STUDIES RELATING TO SHIP ACQUISITION - OVERVIEW

Date	Name Of Study	For	Conducted By	Purpose And Scope
1954	Gates Committee	SECNAV	Navy in-house committee	Review of organizational structure of the Department of the Navy to identify overlapping or duplicative functions, problems and difficultie
1959	Franke Board	SECNAV	Navy in-house committee	Review of organization of the navy in view of DOD Reorganization A of 1958 and technological advances since the Gates report.
1962	Dillon Review	SECNAV	The in-house representatives and consultants	Comprehensive review of entire Navy organization; in-depth review c functions and operations down to and within bureaus and offices.
1966	Shea Report	SECNAV	National Academy of Sciences	Critical review of the procedures associated with formulation of ship characteristics, determination of design, and systems integration of hull, machinery, weapons, and other equipment.
1967	SHIPACS	SECNAV	Navy in-house committee	Verified and examined in detail the key problems identified by the National Academy of Sciences Shipbuilding Study Group.
1969	SCN Pricing and Cost Control Study	SECNAV	NAVMAT	Identify improvements in the shipbuilding and conversion managem system needed to ensure that programmed ships could be acquired within the limits of the Shipbuilding and Conversion, Navy (SCN) appropriation.
1969	Blue Ribbon Panel Report	U.S. President	Panel appointed by Nixon	Study and report on the organization and management of the Department of Defense.
1975	NMARC	SECNAV	Navy and Marine Corps Acquisition Review Committee	Assess the organization, management, staffing, and procedures us by the Department of the Navy in developing and producing major weapon systems.
1978	Naval Ship Procurement Process Study (NSPPS)	ASN (M, RA&L)	Committee appointed by ASN	Examine problem areas which had emerged between the Navy and shipbuilding industry and were relevant to the massive and Controversial shipbuilding claims presented to the Navy in the 1970
1979-1981	NAVSEA SHIP Acquisition Policy Positions	COMNAVSEA	NAVSEA in-house team	Review and analysis of the NSPPS conclusions to determine where policy of procedural improvements could be made and how they cou be implemented.
1979	Workshop on NAVSEA Engineering	COMNAVSEA	MIT Center for Advanced Engineering Study and Consultants	Review the demands on NAVSEA's engineering force in light of personnel ceilings and recommend more effective use of talent.
1982	Ship Design at NAVSEA	COMNAVSEA	NAVSEA In-House Team (Fee, Gale, Lankford, Johnson)	Defined NAVSEA ship design strategy for the 1980's include. desig efficiency, personnel effectiveness, effective use of external resourc

CEC Acquisition Reform Implementation

Doug Crowe
CEC Project Manager
Naval Surface Warfare Center, Crane, IN

Glenn Benninger
Program Manager
VITRO Corporation

Approved for Public Release
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The views expressed herein are the personal opinions of the authors and are not necessarily the official views of the Department of Defense, Program Executive Office (Theater Air Defense), Naval Sea Systems Command, or the Naval Surface Warfare Center Crane.

Abstract

The Cooperative Engagement Capability (CEC) program is actively applying acquisition reform principles to achieve program cost and schedule goals in a complex and dynamic technology environment.

The CEC program management has adopted the tenets of true Acquisition Reform, and is actively implementing these techniques. There is an Integrated Product and Process Development (IPPD) theme, composed of interacting Integrated Product Teams (IPTs). The teams are empowered to apply all the tools of Acquisition Reform, including requiring fewer Contract Data Requirement List (CDRL) deliveries of the equipment contractor, improved electronic communications for transfer of design data and reports, and increased government and contractor teaming to address critical situations and produce quick resolution. The system requirements are documented in a performance specification, which frees designers to focus on implementing system functions using the most appropriate technologies.

The system design utilizes the commercial Versa Module Eurocard (VME) backplane bus standard to integrate processors, communication system components, and supporting systems. Approximately seventy percent of Lowest Replaceable Units (LRUs) in a single CEC cooperating unit are Commercial Off The Shelf (COTS), including the use of COTS processors, memory, and interface boards. The system architecture is open, allowing for expansion of future capability and additional weapon system interfaces. Currently, the CEC is slated for installation aboard all surface combatants, carriers, and LHDs; and aboard E-2C aircraft and LAMPS helicopters. Future plans include land-based and satellite based units.

List of Figures

Notations/Definitions/Abbreviations

ADM	Advanced Development Model
BIT	Built-In Test
BGAAWC	Battle Group Anti-Air Warfare Coordination
CAD	Computer Aided Design
CASS	Consolidated Automated Support System
CDRL	Contract Data Requirement List
CEC	Cooperative Engagement Capability
CES	Common Equipment Set
CM	Configuration Management
COTS	Commercial Off The Shelf
CPFR	CEC Problem Failure Report
CU	Cooperating Unit
DA	Design Agent
DoD	Department of Defense
DoDI	Department of Defense Instruction
EC	Equipment Contractor
EDM	Engineering Development Model
ESD	Electrostatic Discharge
FM	Functional Manager
FMECA	Failure Modes and Effects Criticality Analysis
FRACAS	Failure Reporting And Corrective Action System
FY	Fiscal Year
G&A	General and Administrative
IEEE	Institute of Electrical and Electronic Engineers
IOC	Initial Operational Capability
IPPD	Integrated Product and Process Development
IPT	Integrated Product Team

Notations/Definitions/Abbreviations - Cont'd

ISEA	In-Service Engineering Agent
LAMPS	Lightweight Airborne Multi-Purpose System
LOT	Life Of Type
LRU	Lowest Replaceable Unit
MILSPECs	Military Specifications
NDI	Non-Developmental Item
NSWC	Naval Surface Warfare Center
PEA	Product Engineering Agent
PEO(TAD)C	Program Executive Office for Theater Air Defense
PIDS	Prime Item Development Specification
SECDEF	Secretary of Defense
SOW	Statement of Work
SSA	Software Support Activity
TDA	Technical Direction Agent
VME	Versa Module Eurocard

Background

The Cooperative Engagement Capability (CEC) program began in the mid-80's under the auspices of the Battle Group Anti-Air Warfare Coordination (BGAAWC) program. CEC provides for the exchange of sensor measurement data of fire control quality among all CEC-capable units (known as Cooperating Units or CUs), the subsequent processing of that data by individual units in a manner that provides all CUs with a common air picture, and a high speed communications network of sufficient capacity that is reliable and jam-resistant.

CEC is managed by the Program Executive Office for Theater Air Defense, PEO(TAD)C, and is supported by John Hopkins University/Applied Physics Laboratory as the Technical Direction Agent (TDA), Naval Surface Warfare Center (Port Hueneme Division- In-Service Engineering Agent (ISEA), Crane Division - Product Engineering Agent (PEA), and Dahlgren Division - Software Support Activity (SSA)), and Raytheon's E-Systems Company, ECI Division as the Equipment Contractor (EC)/Design Agent (DA).

Discussion

The Cooperative Engagement Capability (CEC) program is actively implementing the acquisition reform requirements mandated by current Department of Defense policy. This policy is defined in Secretary of Defense (SECDEF) memorandum entitled "*Specifications and Standards -- A New Way of Doing Business*"[1].

Among the major points delineated in the SECDEF memorandum include: (1) "*Performance specifications shall be used when purchasing new systems ... for programs in any acquisition category*"; (2) "*Use commercial specifications and standards in lieu of military specification and standards*"; and (3) "*Reduce direct Government oversight by substituting process controls and non-government standards in place of development and/or production testing and inspection and military-unique quality assurance systems*".

The CEC program institution of acquisition reform can be divided into three major thrusts. These are:

(1) **Acquisition Streamlining**
(2) **Transition to "Commercial Baseline"**
(3) **Commercial Off The Shelf Implementation**

Acquisition streamlining was further addressed in SECDEF Memorandum entitled "*Use of Integrated Product and Process Development and Integrated Product Teams in DoD Acquisition*"[2]. The CEC program has established two levels of integrated product teams (IPTs) to lead CEC development in the areas of design, test, logistics and support.

Acquisition Streamlining

The focus on acquisition streamlining within CEC has concentrated on:

a.) **Integrated Product Teams (IPTs)**
b.) **On-Line Data Access**
c.) **Digital Data Transfer**
d.) **Aggressive Tailoring of DoDI 5000.2**

The implementation of IPTs within CEC is comprised of two levels; an executive IPT and several working-level IPTs. The executive IPT consists of the lead managers from each of the major CEC program activities, including the program office (PEO(TAD)C), the technical direction agent (Johns Hopkins University/Applied Physics Laboratory), the product engineering agent (NSWC Crane), the in-service engineering agent (NSWC Port Hueneme), the software support activity (NSWC Dahlgren), and the design agent (E-Systems ECI). The executive IPT, chaired by PEO(TAD)CB, is the central focal point for overall CEC development, and coordinates among the various working-level IPTs. (See Figure 1.) The primary objective of the executive IPT is to assimilate necessary information and analyses to rapidly resolve system engineering and technical issues and problems.

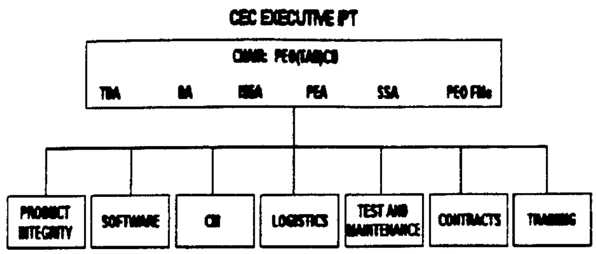

Figure 1. Executive IPT and Lower Level IPTs.

The goal of working-level IPTs is to have government engineers working in focused teams alongside (and on-site) with ECI engineers during the actual development of the CEC. By doing this, the CEC program has gotten an early, upfront assessment on how well the ECI *PROCESS* is implemented and various design disciplines adhered to. It achieves the SECDEF mandate to reduce government oversight by implementing process controls in place of inspection. One example of this was NSWC Crane Division reliability engineers working with ECI reliability engineers on Failure Modes and Effects Criticality Analyses (FMECAs) and Part Stress Analyses. The Navy was able to gain critical insight to the synergy between the reliability and design groups to insure that an effective process was instituted. The Navy is also able to make recommendations for improvement, without having to have ***REDUNDANT CHECKERS, INSPECTORS, and REVIEWERS*** waiting at the end of the pipeline to review and comment to contractor delivered Contract Data Requirements List (CDRLs), and due to the usual CDRL development/review cycle, the comments are usually too late to provide any positive benefit. Also, with early involvement in the development process, the applicable CDRLs, such as FMECA and Part Stress Analysis, were deleted from the contract.

On-Line data access is the second area where the CEC program is streamlining the requirements. The intent of this is to eliminate the need for the contractor to have to develop a CDRL for delivery to the Navy. Instead, electronic access by the Navy into the appropriate ECI database is established so that the Navy can "query", review, and extract the data for analysis, which provides for real-time input into the design of the system, which has allowed deletion of CDRL requirements. Examples of this for CEC includes: access to the Failure Reporting and Corrective Action System (FRACAS) database, access to the CEC Problem Failure Report (CPFR) database, and access to the Mechanical and Electrical Computer Aided Design (CAD) databases. As such, the Navy can examine failure data for trend analysis and reliability growth, evaluate implementation of corrective actions, and perform thermal and stress analyses of the proposed design, all without a single *PAPER* CDRL ever being generated.

Digital data transfer is also being implemented by the CEC program during the next contract phase. For those cases where a CDRL is required, ECI can submit a single soft-copy to the Navy. The CDRL is then distributed electronically to all CEC activities for on-line review and comment. PEO(TAD)C, the Navy field activities, APL, and ECI are electronically connected for the immediate dissemination of information (including CDRLs) across the CEC community. An Information Management System has been developed that integrates a document server, a relational database, and a World Wide Web server ***(http://prophet.nwscc.sea06.navy.mil)*** for accessing CEC documents over the Web or discrete dial-in service via modem.

Finally, aggressive DoDI 5000.2 tailoring and the implementation of the above measures have reduced the number of CDRLs required for the Common Equipment Set (CES) , the down-sized, improved reliability CEC system, contract modification by almost 80%. (See Figure 2.) In addition, utilizing electronic transfer of CDRLs has reduced the estimated number of paper deliveries from over 6000 to less than 50. (See Figure 3.) A rough estimate for cost savings is approximately $10 million.

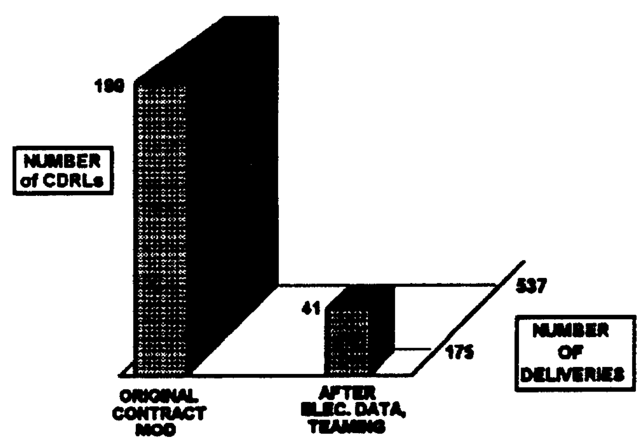

Figure 2. CDRL Reduction.

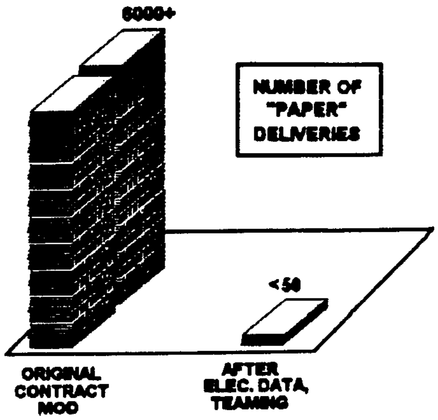

Figure 3. Reduction in Number of Paper Deliveries.

Transition To A Commercial Baseline

The CEC program's transition to a commercial baseline achieves two goals of the SECDEF memorandum: (1) to use performance specifications and (2) use commercial specifications and standards. There are three distinct documents that this directive impacts:

a.) **System Specification (the "A Spec")**
b.) **Segment and Prime Item Development (PID) Specifications**
c.) **Statement of Work**

Each requires a different approach to achieve the SECDEF directive.

The System Specification, or "A Spec", for CEC is impacted by the SECDEF requirement for performance specifications. As such the System Specification defines the functional, performance, and environmental requirements that ECI must meet with the CEC equipment design. The key point here is that the System Specification defines the *ENVIRONMENT* in which the CEC equipment must operate, *NOT* the design implementation that ECI must use. Therefore, design implementation requirements, and the associated military specifications that defined the materials, design processes, and parts, were deleted from the System Specification and are described in lower CEC specifications, which are the contractor developed Segment Specification and Prime Item Development Specification (PIDS). The Navy does not impose design restrictions upon the contractor to meet the Navy developed functional, performance, and environmental requirements.

The second impact on the System Specification is the removal of military specifications and standards. Two methods were utilized to accomplish this. First, is the direct inclusion of performance and environmental requirements into the system specification. For example, the requirement that the CEC must meet the "vibration requirements for Level 1 of MIL-STD-167" is replaced by the two to three paragraphs that define the vibration levels that the CEC equipment must meet. The second method was the replacement of military specifications by the applicable commercial specifications. Existing interface requirements, such as to other Combat Systems, ships power and cooling, and combat system safety force CEC to retain some military specifications. The end result of these efforts reduces the number of referenced military specifications from forty-six to eleven. (See Figure 4.)

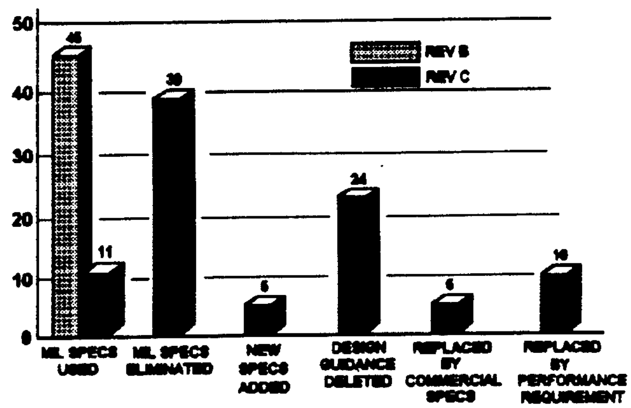

Figure 4. Military Specification Reduction.

The transition of the System Specification to a performance based document gives ECI the design latitude necessary to provide the most cost effective design that their expertise can achieve. The specific design methods that the contractor chooses to utilize to meet the System Specification will be documented in the Segment Specification and PIDS. The contractor may choose to utilize commercial or military specifications in their design implementation. Necessary tailoring to any military specifications will be contained within a separate appendix to these specifications, which are CDRL deliverables with approval by the Navy.

The typical Statement of Work (SOW) defines the contractor's work baseline by the use of "programmatic" military specifications and standards. Examples of these include MIL-Q-9858, Quality Program, MIL-STD-785, Reliability Program, MIL-STD-965, Parts Control Program, MIL-STD-882, System Safety Program, MIL-STD-1686, Electrostatic Discharge (ESD) Program, etc. The intent of acquisition reform is to delete the global use of these "programmatic" military specifications and standards by allowing latitude for contractors to utilize existing in-house procedures or commercial standards.

The CEC SOW was originally developed as a tailored DoDI 5000.2 instruction that had each military specification specifically tailored each to the essential requirements necessary for program execution. For example, the contract allowed ECI to utilize ISO-9000 (the commercial quality standard) *OR* MIL-Q-9858. Likewise, only 50% of the tasks for MIL-STD-785, Reliability Program, were called out by the contract. The CEC SOW was re-written to delete the programmatic military standards and specifications. The SOW requires the contractor to develop (and submit for approval) a program plan for that discipline which insures that the contractor will meet the requirements of the System Specification. Taking reliability for example, instead of calling out the tasks of MIL-STD-785 the SOW will have a paragraph which reads:

> 3.21 RELIABILITY PROGRAM. The contractor shall develop and institute a reliability program to insure that the Common Equipment Set (CES) System meets the reliability requirements of [the system specification]. At a minimum, the reliability program shall address (specific elements that need addressed by the contractor in the program plan).

This method allows the contractor to utilize his existing in-house program plans to meet the System Specification requirements for the CEC system. This is the primary method CEC used to replace the programmatic military specifications within the SOW. With the completion of this effort, the number of military specifications called out by the CEC contract drops from eighty to eight. Remaining specifications, such as System Safety Program (MIL-STD-882), Logistics Support Analysis (MIL-STD-1388-1A), and Defense System Software Development (DOD-STD-2167A), could not be removed or replaced by commercial standards due to being unique to the military. (See Figure 5.)

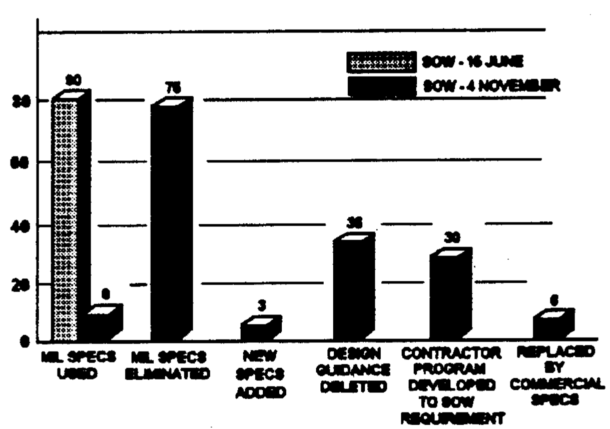

Figure 5. CEC SOW Military Specification Reduction.

Cots Implementation

The utilization of Commercial Off The Shelf (COTS) and Non-Developmental Items (NDI) is being actively pursued by the CEC program. Currently, the CEC is heavily utilizing COTS processors and memories to achieve the processing capability required for the CEC performance. As an example, the five deployed ADM/EDM systems have $2.5 million worth of COTS and NDI. (See Figure 6).

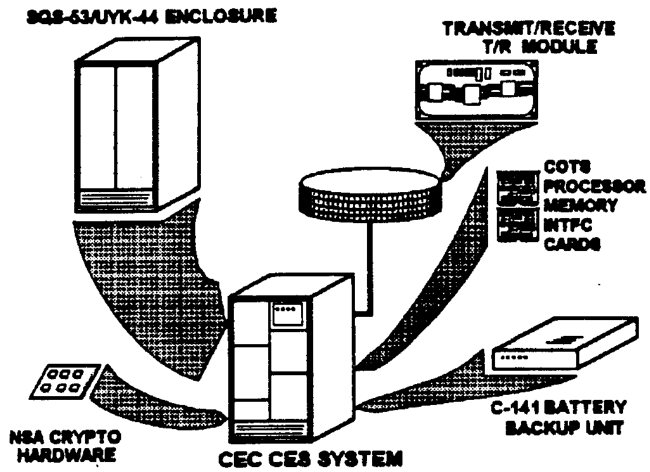

Figure 6. CEC COTS and NDI.

CEC is designed around a commercial open system (VME - IEEE 1014). CEC COTS usage is moving from 40% of the system to 60% of the system by FY97. While COTS and NDI currently play an extremely key role in the success of CEC, the CEC program is focusing on the increased use of COTS, along with cost and risk reduction efforts to insure the successful use for IOC and CES full rate production. These measures include:

a.) **COTS Survivability**
b.) **Open System Architecture**
c.) **Open System Conformance**
d.) **COTS Supportability**
e.) **COTS Procurement Process**

COTS survivability is the ability of the COTS boards to withstand the rigors of a military environment. With the System Specification defining the environment in which the CEC equipment must survive, the onus of COTS surviving AND OPERATING in that environment rests with the enclosure and packaging concept. Therefore, the developed enclosure provides the necessary environmental isolation for the COTS boards to survive. The CEC program is investigating the limitations of the environment envelope that COTS boards will survive and operate in to determine

the most cost effective enclosure and packaging concept for the CES shipboard and airborne systems. (See Figure 7.)

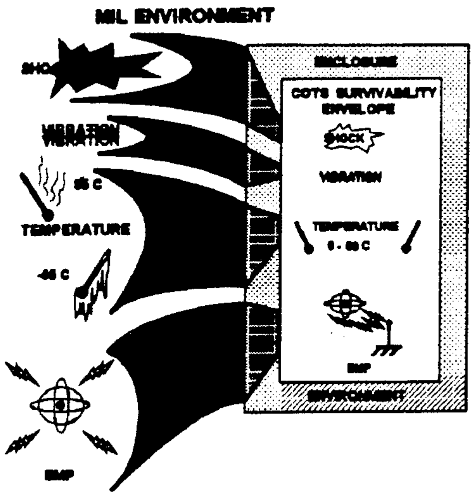

Figure 7. CEC Packaging for Environmental Effects Mitigation.

An Open System Architecture is a collection of interacting hardware and software open standards that are integrated to meet the mission requirements of the system. CEC has striven to develop the most effective selection of commercial backplane busses, operating systems, and interconnect (network) concepts to ensure wide availability of COTS products and established suppliers. For example, in the case of the backplane busses, the CEC program is utilizing the Versa Module Eurocard (VME) bus. This bus provides sufficient throughput, the ability to expand, and a wide availability of VME products and established suppliers. It is the dominant industrial form factor for embedded computer equipment.

Open System Conformance means defining the system application profile by documenting the mandatory and optional features of the VME bus specification by the CEC program, selection of COTS products based upon the ability of product to meet the system application profile, and assessment of multi-vendor product compatibility. This approach provides the engineering knowledge necessary to choose compatible products throughout the life cycle of the system, including technology insertion, upgrades, second sources, and alternative sources to overcome obsolescence problems.

COTS "supportability" is of prime importance to the CEC's long-term success. As stated earlier, with $2.5 million worth of COTS and NDI currently in CEC, COTS is currently deployed, and supported, in the field. Therefore, the focus is on two areas:

a.) **Test and Repair**
b.) **Upgrade/End-of-Life**
- **Hardware**
- **Software**

CEC is examining the inclusion of test and repair capability of COTS boards into the fleet maintenance system such as the use of the Consolidated Automated Support System (CASS) tester. It may be economically advantageous to develop screen test capability for COTS cards utilizing their internal BIT capability. If the Microminiature (2M) Repair program provides sufficient assets, repair of COTS boards in the fleet may be a reality for CES systems.

However, it is a given that COTS boards will have frequent upgrade and end-of-life cycle. It is this area, possibly utilizing some of the Open System Conformance characterization mention earlier, which will allow the CEC program to make informed decisions regarding a Life-of-Type (LOT) buy versus upgrade by having a well defined interface that will allow evaluation of hardware and software permutations. An ongoing market surveillance and technology assessment will support these decisions by providing the CEC program management office with current and projected industry trends and developments that may affect current hardware or software choices.

One final COTS area is procurement practices. Most major defense contracts lump all material procurement by defense contractors into a single cost structure that forces the contractor to apply significant markup (G&A, Overhead, etc.) to the otherwise unmodified COTS product. The CEC program has proposed a new cost accounting standard which separates COTS products from raw materials and piece parts to reduce the markup applied by the equipment contractor. This will result in significant cost savings to the Navy on high percentage COTS based systems such as CEC.

Summary

In conclusion, due to the aggressive schedule that the CEC program is working to, significant progress has been made toward the implementation of acquisition reform policy within the Department of Defense, with regards to acquisition streamlining, transition to a commercial baseline, and COTS utilization. FY96 will continue the focus on these various elements in an effort to reduce program costs while continuing to meet performance and environmental requirements.

Acknowledgments

Mr. Kenneth Keene (PEO(TAD)CB), Mr James O'Brien (VITRO Corporation), Mr. Duane Embree (NSWC Crane Division) and many others involved with development of the CEC provided information and suggestions for the development of this paper. We appreciate their help.

Endnotes

[1] Secretary of Defense (SECDEF) memorandum "*Specifications and Standards -- A New Way of Doing Business*" dated 29 June 1994.

[2] SECDEF Memorandum "*Use of Integrated Product and Process Development and Integrated Product Teams in DoD Acquisition*" of 10 May 1995.

Carl Douglas "Doug" Crowe received a Bachelor of Science in Electrical Engineering degree from Rose-Hulman Institute of Technology in 1983 and has worked at Naval Surface Warfare Center, Crane Division (NAVSURFWARCENDIV Crane) since that time. Mr. Crowe initially began work on the SSN-751 flight AN/BSY-1 Submarine Combat System as an electrical engineer focusing on circuit card standardization, testing, production issues, and other hardware requirements. He later become the NAVSURFWARCENDIV Crane project manager for the SSN-21 AN/BSY-2 Submarine Combat System, focusing on electronic module documentation, testability, enclosure selection, and design evaluation testing program. Since 1993 he has been the NAVSURFWARCENDIV Crane project manager for the Cooperative Engagement Capability (CEC) program, focusing on system requirements definition, system design, including the transition of Commercial Off the Shelf (COTS) and other advanced technologies into the CEC program, system acceptance testing, and associated logistical issues.

Glenn D. Benninger received a Bachelor of Science in Electronics Engineering from the University of Louisville in 1981. He was a cooperative intern at Naval Surface Warfare Center, Crane beginning in 1979, and continued working there after graduation in automatic testing and module engineering until 1989. He went into private industry in 1989, working as a contractor. He has worked for Vitro Corporation since 1992 as a program manager on NSWC Crane's Omnibus electronics contract providing project assistance to a variety of Navy programs.

LPD 17 Designing for Ownership

Authors
CAPT Maurice Gauthier, USN
Ms. Connie Gragan Clavier
Amphibious Transport Dock Ship Program Office (PMS 317)
Naval Sea Systems Command

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The views expressed herein are the personal opinions of the authors and are not necessarily the official views of the Department of Defense or the Naval Sea Systems Command.

Abstract

Designing a ship that is affordably supportable is one of the four cornerstones of the LPD 17 Program Office. Through the 1970's the Navy's approach to the design and construction of ships was "design *then* build." This approach resulted in delays and cost overruns due to designs that were not easily produced the first time. In the 1980's, the Navy's shipbuilding programs began to use computer aided engineering (CAE) through the application of computer aided design and computer aided manufacturing (CAD/CAM). This was the beginning of a "design *for* build" paradigm. The transition experienced cultural and physical difficulties typical of rapid deployment of any new technology. The anticipated returns on this transition lagged expectations, but not by much. Ultimately, many improvements in the design and construction process were realized with this strategy. This technology is now mature, and the acquisition investment has been justified.

The next step is to build upon these investments and achievements to extend our cost reduction targets beyond procurement and across the entire life cycle of the class. In 1996, TEAM 17 is "Designing for Ownership." TEAM 17 will take ship acquisition into the 21st century by defining the owner's long term supportability needs as a cornerstone of LPD 17's acquisition strategy at the very outset.

Whatever the LPD 17 Class ultimately costs to produce, it will cost the Navy twice that amount to own and operate this class over its service life unless we fundamentally change how we do business.

To change how NAVSEA does business, TEAM 17 will link working, state-of-the art information technologies with reengineered processes. This will build long term partnerships with the industry and the user community from the beginning and form the establishment of aggressive life cycle cost reduction targets across the life cycle chart of accounts. TEAM 17 is designing the first 21st century ship with the operator, the maintainer and the trainer actively participating in the design and total ship integration process.

This paper discusses the significance of life cycle support planning during the early phases of design and integration. It will focus on maintenance, training, manpower, and life cycle cost considerations that must be addressed during design and what TEAM 17 is doing to field an affordable supportable class of ships that will serve until the middle of the 21st Century. Another TEAM 17 cornerstone is technical adaptability. The challenge to design and integrate this class of ship to adapt to rapidly unfolding technology over its life cycle is equally important and challenging. However, this paper will concentrate on life cycle costs other than modernization.

List of Figures

Abbreviations

Ao	Operation Availability
ASMP	Advance Surface Machinery Program
ATIS	Advanced Technical Information System
AUC	Average Unit Cost
BFTT	Battle Force Tactical Trainer
BIT	Built-in-Test
CAD/CAM	Computer Aided Design and Computer

	Aided Manufacturing
CAE	Computer Aided Engineering
CALS	Continuous Acquisition and Life Cycle Support
CBM	Condition Based Maintenance
CBT	Computer Based Training
CFE	Contractor Furnished Equipment
CIITA	Computer Improved Instructor Training Aid
CNO	Chief of Naval Operations
DIS	Distributed Interactive Simulation
DOD	Department of Defense
FSC	Full Service Contractor
FYDP	Future Year's Defense Program
GFE	Government Furnished Equipment
ICAS	Integrated Condition Assessment System
ICW	Interactive Courseware
IETM	Interactive Electronic Tech Manual
IMP	Integrated Master Plan
IPDE	Integrated Product Data Environment
IPPD	Integrated Product and Process Development
JTCTS	Joint Tactical Combat Training System
LSAR	Logistics Support Analysis Record
MAM	Maintenance Assist Module
MILCON	Military Construction
MILPERS	Military Personnel
MIRWS	Master Integrated Resource and Work Schedule
MLDTs	Mean Logistics Delay Time
MOE	Measure of Effectiveness
NAVWCTSD	Naval Air Warfare Center Training Systems Division
OBRP	On Board Repair Part
O&MN	Operations & Maintenance, Navy
O&S	Operational & Support
OPN	Other Procurement, Navy
OPNAV	Naval Operations
ONR	Office of Naval Research
OODB	Object Oriented Data Base
ORD	Operational Requirements Document
PMS	Planned Maintenance System
R&D	Research & Development
RCM	Reliability Centered Maintenance
ROC/POE	Required Operational Capability/Projected Operating Environment
SCN	Shipbuilding and Conversion, Navy
SNAP	Shipboard non Tactical ADP
TEE	Training Effectiveness Evaluation
VTC	Video Teleconferencing

Background

Acquisition reform has been a perennial feature of DOD rhetoric for over a decade. Previous cycles of reform have tended to be focused inward, seeking solutions within government structures and practices, frequently trying to adopt commercial business practices without understanding the underlying principles. A "One-size fits all" mentality prevailed, and if some reform technique was good, more was better, and the most was best. At best, these reform cycles have produced marginal cost reductions. In some cases, the reductions occurred in acquisition only to resurface as ownership cost drivers. The current fiscal environment mandates large savings. Large means savings on the order of 20%-30%. Large savings demand radical change to how we do business. The Shipbuilding and Conversion, Navy (SCN) account is shrinking, dramatically declining 75 percent over the last ten years. In 1985, the Navy/DOD bought 23 ships. In 1995, the Navy bought six. The new construction budget to recapitalize our fleet is austere, and counting on large outyear windfalls is unrealistic and borders on irresponsibility. In FY 96 through FY01, planned ship construction is well below the requirement to sustain required force levels. The requirements and budget are not in balance. Ship construction funding levels are forecasted to be about half what is required to maintain the required force level. The Navy now faces a major shipbuilding "Bow wave" problem at the turn of the century, when the aging ships must be replaced. In October 1995, VADM Bowes stated, "Our biggest challenge... OUR biggest challenge ... is to help reduce the height of the *bow wave* by building new ships and systems that not only have an affordable sticker price, but also have low ownership cost." He spoke of major reductions in life cycle costs of 20, 30, 40 and 50 percent.

We must find ways to be able to afford to buy twice the number of ships that we are buying today within likely funding levels. In terms of Hope's First Law of Shipbuilding, assuming a ship should last 35 years, to maintain a 350 ship Navy (including submarines) the Navy must procure at least 10 ships and submarines per year. Our current FYDP calls for, on the average, 5 new ships and submarines per year. At the current rate, we

can expect to only maintain a fleet of 150-200 ships. The cost to own existing ships competes, within the Navy's total obligational authority, for the funds required for recapitalization. To break this downward spiral we must design tomorrow's ships with large reductions in the costs of ownership. We must change the way we support/maintain the operating fleet on a day-to-day, refit-to-refit basis. We simply can not afford the existing ways of doing business.

Figure (1) illustrates how ownership costs of an aging fleet rank with acquisition costs.

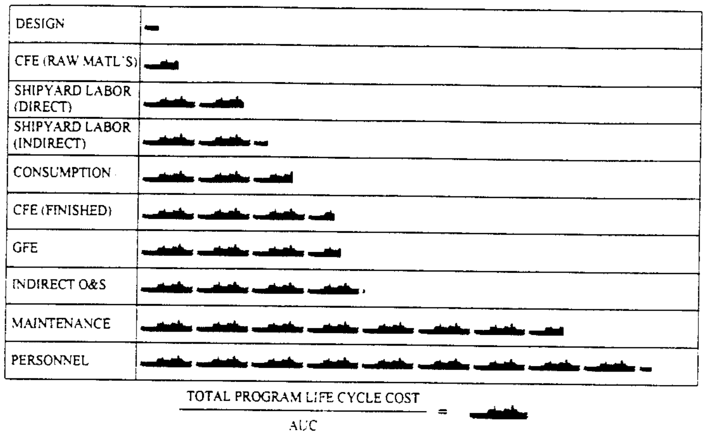

Figure 1

The Navy needs to focus on total life cycle cost effects in early planning and decision making. When confronted with a mandate for large cost reductions in both the near term and over the life cycle, without the benefit of near term investment capital, "tweaking" existing practices and processes will not produce the required results. Large reductions call for drastic change in both processes and culture. Change of this magnitude requires an organizational willingness to identify, quantify and manage risk. The desired goal requires a much greater return on our R&D investments and ship design and integration funds than the Navy has ever achieved in the past. This man dates levels of cooperation that did not exist during the budgets enjoyed enroute to the 600 ship Navy. The processes and practices that were very effective during that expansion are among the greatest handicaps today. These simple observations mandate a fundamental reengineering of the processes by which the Navy will meet the warfighter's requirements. The time for reengineering is now. The team for reengineering is TEAM 17. In parallel with reengineering efforts, the Navy must radically change how it looks at information technology. As opposed to an expenditure, information technology must be viewed as an investment. That investment capital must be steered toward our most successful reengineers whose processes promise the greatest return on that investment. Applying state of the art information technology to existing, inefficient processes is not smart. This wastes precious resources and misses large potential savings. By looking to the "Road Ahead" in information technology and beginning with today's technology, the Navy will position itself to assimilate tomorrow's technology as the engine that drives the reengineered processes. Those of us in the Navy must look to tomorrow's technology to work smarter to realize efficiencies and savings that have not been conceived of today. We need to reduce the number of people it takes to operate the fleet and achieve large reductions in the maintenance burden experienced. We need to use the equipment onboard our ships to train more effectively and improve operator performance. To do this, we must change our acquisition planning to include early life cycle partnering with industry and place critical focus on streamlining our existing processes.

We have read and heard many calls for acquisition reform to achieve the Navy's goals of "right sizing", "reduced manning," and "reduced life cycle cost" while "maintaining the readiness of the fleet." The message is clear. The time is now. You can see examples of this reform in mature programs like AEGIS, in Research and Development (R&D) projects at the system equipment level like the Advanced Surface Machinery Program (ASMP), in programs to improve the operation and maintenance of existing shipboard systems such as the Integrated Condition Assessment System (ICAS), in next generation ship acquisition programs like the Surface Combatant (SC) 21 and indeed in the first ship to be delivered in the 21st century, the LPD 17 Amphibious Transport Dock Ship.

LPD 17 Program Background

LPD 17 is the newest class of amphibious warships that will perform various expeditionary missions. It is the functional replacement for 41 ships of the LPD 4, LSD 36, LKA 113 and LST 1179 classes. These ships will reach the end of their extended service lives between the years 2000 and 2010. The LPD 17 will incorporate state-of-the-art expeditionary warfare ship-self defense systems, radar cross section reduction, distributed system architecture, and total ship system integration, with emphasis upon reduced ownership costs.

LPD 17 was designed with four fundamental principals:

1. Warfare Capable: Meets all stated operational requirements.

2. Mission Flexible: Readily adaptable to the full range of Navy-Marine Corps, Joint Service and NATO expeditionary warfare missions.

3. Technically adaptable: Designed for rapid, affordable performance upgrades throughout the life of the ship.

4. Supportable: Reliable, maintainable and affordable throughout the life of the ship.

The concept behind building the LPD 17 is a different approach than previously used when building ships. The differentiating premise is that a cross-functional group of people representing NAVSEA , the Industry (shipbuilders, vendors, integrators, and suppliers), and the Operational Forces form a co-located Integrated Product and Process Development (IPPD) team to perform the detail design, total ship system integration, construction, testing, logistics and life cycle support planning for the LPD 17 ship class. The LPD 17 Program Office (PMS 317) was established in November 1994. TEAM 17 was formed shortly thereafter. *Figure 2* depicts the notional IPPD Team for LPD 17.

LPD 17 Integrated Product and Process Development (IPPD) Team Approach (Notional)

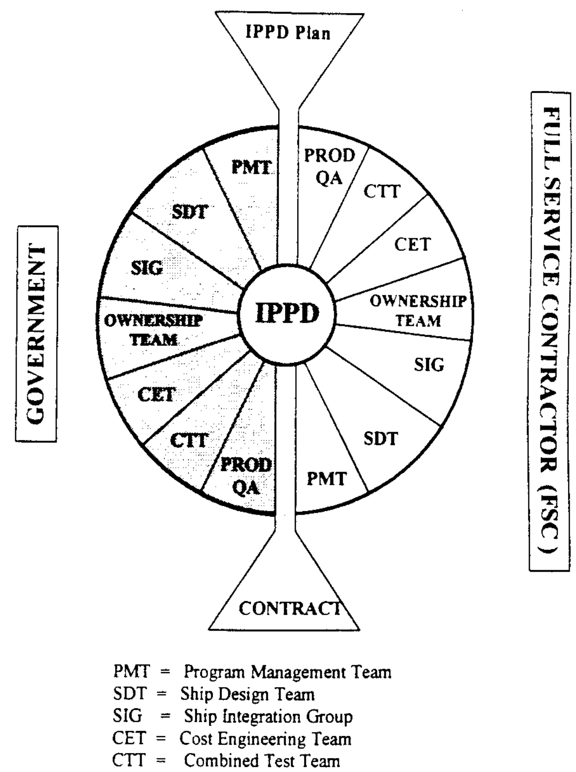

Figure 2

In order to perform the detail design, total ship system integration, construction, testing logistics and life cycle support planning for the LPD 17 ship class while using the IPPD concept, the team will need to share geographically dispersed product information. This information could be contained in CAD drawings, the ship system data element dictionary, product drawings, program data, etc. The challenge then is to provide numerous people, using a myriad of different systems, accurate access to each other's information on a real time bases.

Information Technology

CALS is no longer just a vision, it is a reality. Creating an integrated database which geographically distributes information will be commonplace before the LPD 17 design will be complete. The optimal solution to the data distribution and access challenge for the Navy and LPD 17 is the Integrated Product Data

Environment (IPDE). An IPDE is a geographically distributed but logically connected database of product information at the equipment, system and platform levels that is shared by industry and government. The IPDE will provide a multi-media object oriented database (OODB) capability containing design analyses, 3D models, 2D CAD drawings, logistic data, maintenance and test procedures, test results and data, parts specifications, videos, Interactive Courseware (ICW), maintenance history and parts usage data, program schedules, material ordering requests, etc. This information is indexed and distributed among government and industry to support multiple disciplines.

Figure 3 shows a notional IPDE environment for LPD 17.

Life Cycle Vision

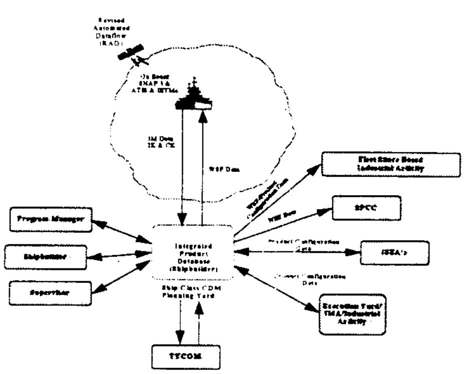

Figure 3

Data would reside at industry and government sites and be logically integrated. This approach respects the autonomy of ADP resources at each site, while integrating them into an enterprise level IPDE. Billions of dollars have been invested by the Navy and by industry in legacy data management systems. In this IPDE scenario, those systems could be used. The Navy must leverage that investment in these austere times. Access to a distributed IPDE will be shared by industry and the Navy. The LPD 17 IPPD team will use the IPDE for *consequential engineering* similar to the way LSARs theoretically were used with previous data-driven systems. User-friendly, plain-English software tools that interact with an IPDE to satisfy real time user requests for technical information will be available. An electronic document manager is envisioned to catalog and route types/sources of information available in the IPDE. From a user's perspective, there should be no distinction between engineering/design products, logistics products, and operating/maintenance data. The Navy spends too much time and money repackaging information into logistic products, and operating/maintenance data.

Information distribution and access controls require special considerations in a multi-site IPDE. Operational units will have a local extract of frequently used IPDE information while deployed. Requests for special information, not available in the deployed IPDE extract, could be satisfied through remote queries via satellite communications links (if the tactical situation permits). For example, Navy Shipboard non-tactical ADP (SNAP) and Advanced Technical Information System (ATIS) computers are being deployed on Navy ships to access multi-media information. Design change packages will be prepared and delivered digitally in the IPDE. The IPDE of deployed ships can be updated automatically via communications links; eventually eliminating the delay and cost of physically distributing CD-ROMs.

IPDE, combined with broadband communication links to transmit multi-media information, creates new possibilities for dramatically improving support for operating units. The IPDE can provide technical information immediately upon request from operating forces to: (1) support configuration control, (2) automate allowance generation, (3) expert maintenance consultations, (4) special training exercises; (5) medical assistance; and (6) multi-media Video Teleconferencing (VTC) and much more. The AEGIS Program has extended techniques to move administrative functions (e.g. personnel, medical, supply and record-keeping) ashore at considerable life cycle cost savings from reductions in crew size. The U.S. Navy Pacific Fleet has demonstrated remote borescoping of LM 2500 Gas Turbine Engines from shore sites. These types of innovative applications result in deploying the "right sized" warfighting capability.

Integrated Logistic Management Concept

The LPD 17 support concept is designed to ensure that logistic planning and product development is in concert with the system engineering process throughout the service life of the ship and is accomplished through the use of IPPD teams. It requires a fully integrated program which began at concept development and will continue through detail design, ship system (including GFE) integration, construction, testing and life cycle support planning. It requires that all data be developed once and be used again and again in the Integrated Product Data Environment (IPDE); all plans and processes be contained in the Integrated Master Plan (IMP); and all schedules be contained in the Master Integrated Resource and Work Schedule (MIRWS).

Configuration Management and Control

The importance of Configuration Management cannot be over emphasized. The ship's configuration determines all logistics support including on board repair parts (OBRPs), required planned maintenance (PMS), technical manuals, drawings, etc. Inaccurate configuration and inadequate configuration control drives inaccurate logistic support; a problem compounded through each overhaul/repair cycle. Commanders, Naval Surface Forces, Atlantic and Pacific have stated that lack of configuration control and management is the # 1 readiness problem in the fleet today.

The Navy has defined configuration management as the technical and administrative direction and surveillance actions taken to identify and document functional and physical characteristics of an item; to control changes to an item and its characteristics; and to record and report the change process and implementation status. This definition is not complete. True configuration management cannot be obtained without integration of engineering & logistic products via total automation or procedural control or a combination of the two. In a totally integrated system, all information would be stored in database form with none stored in drawings. The purpose of this is to prevent the artificial segregation of information that drawings create and the geometric relationships conveyed by the drawings. Information would be stored one time in one place and interpreted in any of a dozen contexts. To support a single location view, subsystems would be built to generate drawings from the database rather than linking the database to a collection of segregated drawings. This approach means that a user can extract a drawing from a database at any time with confidence that if any changes occurred in the system, the drawing would reflect such changes without the effort of going and finding what has changed. In drawing-centered systems, any change requires that a designer know all of the drawings that are affected by a proposed change. When one drawing changes and others are not changed there is no inherent linkage between the objects on the drawings. In a data centered view, the drawings are consequences of the database, and there is intimate knowledge of every element affected in every presentation context. A key point to the data-centered approach is the higher level of reusability of information. If information is concentrated in drawings, the many unique areas make it difficult to parse the reusable information out of the total data available. In a data-centered approach, the basic information about the objects and components within a project can be reused on another area even if it looks different or is placed differently. Using a data-centered approach to configuration management and control would reduce process time and significantly increase the accuracy of the data to support the system or equipment, thus eliminating costly errors in procuring logistic support.

LPD 17 configuration data will be contained in the IPDE and support a data-centered approach to configuration management and control. We have estimated an ownership cost avoidance of at least one third due to this change in configuration philosophy.

Manning Reductions

Manpower is the single largest cost factor of operating a ship throughout its life cycle. 89% of manpower requirements are established at Milestone I. See *figure 4* below.

"UNDERSTANDING LPD 17 OWNERSHIP COST"

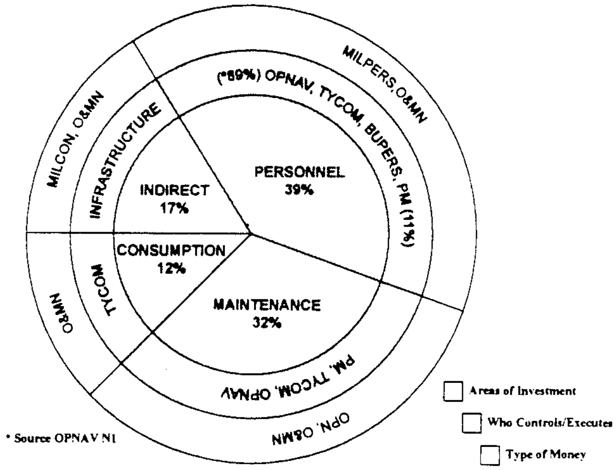

Figure 4

Manpower /manning requirements are established by the Mission Need Statement, the Required Operational Capability/Projected Operating Environment (ROC/POE), and the Operational Requirement Document (ORD). Drivers of manpower are traditionally operational watch stations, maintenance, own ship support, allowances/training, and directed requirements. For an Amphibious Ship maintenance and own ship support account for more than 50 % of the allocated man-hours. Conversely, a Destroyer's manning is driven by operational watch stations.

In late September of 1995, Admiral J.M. Boorda, USN, CNO said "For my entire thirty-nine year career, we always talked about buying ships and manning them with people....I think we need to think about things differently now. We need to figure out how to have the fewest number of people possible, and then build [ships] to make them as effective as they need to be." In late 1995, the Naval Research Advisory Committee reported on reduced ships manning efforts to Admiral Boorda. The Committee concluded two things. First, "Technology is not a roadblock---manning can be reduced substantially using proven demonstrated technology." Secondly, " The roadblocks are to be found in culture and tradition: Incentives and deterrents and self-imposed policy." The average annual cost of one person for one year is approximately $50K .. Multiply that by the total number of sailors in the fleet today and you will begin to understand why the largest cost driver is manpower. To field the fleet we must strive to determine the right size of our fleet today.

Manpower *creep* is a reality. CG 47 class has experienced a 21% increase in requirements since 1981. FFG 7 has experienced a 16 % increase, LHA an 18% and LHD a 10% increase since delivery of the lead ships of each class. Efforts to reduce manning have had mixed success: The LHA automated steam plant did not meet our expectations. The Fleet demanded manual backup. FFG 7 shore-based maintenance did not achieve our goals, and personnel were added to the ship to compensate for the shortcomings. The manning *creep experienced in the initial fielding of* surface combatants and amphibious ships has caused large operational and support cost increases. We must take radical steps to stop it and use the dollars saved to recapitalize our fleet. See *figure 5* below.

CREW INCREASE AFTER DELIVERY

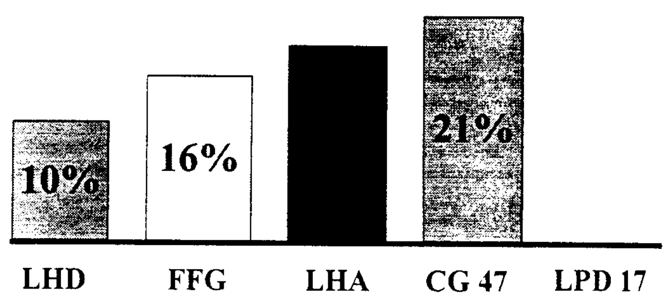

Figure 5

Manpower reductions must start at the inception of a program. Early Program Manager emphasis on life cycle support is necessary to effect an optimum manning scenario. The life cycle costs of manning must be a measure of effectiveness in system trade-off studies. In the future, manning must be considered as a candidate Key Performance Parameter (KPP) in the Acquisition Program Baseline (APB) for ship acquisitions. A systems engineering process approach must be used to manage the design and support of the ship. Senior management must lead the effort to reduce manning and lastly, traditional and cultural barriers must be overcome.

TEAM 17's first concern is to design a ship to meet warfighting space and manpower requirements necessary to operate and maintain the ship.

TEAM 17 has implemented an acquisition strategy which requires that life cycle cost considerations, including proposed manning, be evaluated during the contract design phase and ramping quickly during the detail design and continuing throughout the life of the program. An iterative systems engineering approach to achieve the proper balance between operational, economic, and logistics factors to reach the most cost effective and operationally suitable mix of manpower is being used. Continuous involvement by the operator, maintainer and trainer is accomplished through the Integrated Product and Process Development Team. A cap has been set for manpower requirements aboard ship, with priority to warfighting functions. Will these steps alone ensure the correct number and mix of manpower for LPD 17? The answer clearly is no. LPD 17 will use the latest technology to integrate and automate functions to minimize watch stations. Team 17 will work with OPNAV to eliminate all unnecessary functions, reduce the number of specialists required , increase the knowledge of the generalist through cross-training and reduce the burden on the fleet for as many functions as possible. TEAM 17's acquisition strategy will allow the Full Service Contractor (FSC) team mates to develop a continuous manpower re-engineering effort that uses simulation modeling to optimize shipboard tasks. Fault diagnostic capabilities will be increased (potentially to a zero ambiguity group), shipboard maintenance actions will be reduced, and much more. But, the most important factor and the largest impact will come from the Fleet through breaking the cultural barrier. Until Type Commanders, Commanding Officers, and deckplate sailors commit to operating and maintaining our ships and weapon systems differently, *little change will occur*. And manpower *creep* will continue into the Navy's 21st Century ships..

Maintenance Reductions

Operational Availability (Ao) is a key measure of a ship's material readiness to perform its mission. Amphibious ships have realized an average 78% readiness state over the past 15 years. The major contributor to non-availability can be attributed to combat systems (47%), the second significantly contributing factor is Exterior Communications (26%). Although systems/equipment's are being designed to be more reliable and to require less maintenance, NAVSEA still needs to work harder to bring about radical change in the mandays required to maintain the fleet.

Examples of maintenance problems at the shipboard level include: a preponderance of time-directed tasks that may create problems that did not exist before; poor maintenance access to effect repairs thus doubling or tripling the time required to perform a maintenance action; outdated technical documentation; absence of proper spares and consumables ; and, inadequate training which also contributes to operator-induced failures and increased man-hour expenditure. Intermediate and depot level problems include poorly trained technicians; non-consolidated centers of excellence; unstable labor rates; declining workloads; inefficient work planning; under-utilized workforce; and lack of quality control creating the need for rework.

Other systemic maintenance support problems include lack of effective supply support: exorbitant Mean Logistics Delay Times (MLDTs) (the time it takes to get a repair or replacement part from the supply system) and lack of intra-Navy standardization and the resultant parts proliferation.

LPD 17 intends to overcome the technical problems through use of new technologies such as modeling and simulation during detail design to visualize, through virtual space walk-through, maintenance access obstructions and safety hazards. Total ship Built-in-Test (BIT) for fault isolation will reduce the use of Maintenance Assist Modules (MAMs). Interactive, embedded electronic maintenance and training aids will improve the effectiveness of the crew. Video Teleconferencing (VTC) will bring shore-based knowledge to the platform; and, increased reliance on CBM and use of electronic condition monitoring will eliminate work while increasing system readiness.

The Armed Forces traditionally use Reliability Centered Maintenance (RCM) to maintain the inherent reliability of a system or equipment based

on its design. If a design is not reliable, then no amount of preventive maintenance will make the system more reliable, only design improvements can increase inherent reliability. RCM emphasizes *preventative* maintenance action, rather than *corrective* maintenance actions. Corrective maintenance is used to repair failures *after* they occur. Preventative maintenance, activity intended to prevent functional failures, may be one of three types: time-directed, condition-directed or failure-finding .

In the past, the Navy did not heavily rely on Condition Based Maintenance (CBM) because of the lack of tools to collect and access equipment performance data and material condition. In the mid 70's, the Naval Sea Systems Command began development of a condition monitoring system and tested the concept on the LM 2500 Gas Turbine. The concept failed, largely due to the inadequacy of the computer equipment available from 1974 to 1977. However, advances in digital data processing and sensor reliability have produced renewed focus on condition monitoring. The use of high-speed microprocessors allows us to check sensor errors, process expert algorithms, and interface with information databases such as electronic technical manuals. These added capabilities , packaged in a low-cost and reliable platform, have the potential to generate significant cost savings by avoided maintenance and improved efficiencies. The Integrated Condition Assessment System (ICAS) provides the capability to monitor performance indicators on a real-time basis through on-line sensor input, or on a periodic basis using manual sensor input, and to perform trend analysis based on stored data. ICAS provides shipboard engineers with the necessary knowledge to make CBM decisions to effectively manage platform readiness within budgets. ICAS technology eliminates "fear based" maintenance allowing more effective equipment management at the "O" level thereby automatically shrinking the scope identified for "I" and "D" level maintenance. This is consistent with the reduction of fleet assets and chorused support activities and overall support costs. LPD 17 will rely heavily upon ICAS as an enabling tool for cost reductions and increased reliability.

LPD 17 design initiatives to reduce the Fleet maintenance burden include the use of titanium piping for auxiliary sea water and firemain systems to significantly reduce erosion/corrosion; recessed electrical fixtures which reduce maintenance and improve electrical safety; fiber optic lighting which increases reliability with virtually non-existent maintenance demands; and use of corrosion technology to reduce well deck maintenance.

Additionally, the LPD 17 life cycle support strategy will centralize and combine maintenance and modernization planning to extend the ship's operational cycle and optimize availability's using alternative support strategies that increase parts availability's and establish technical centers of excellence for maintenance and training support.

LPD 17 maintenance planning initiatives are projected to achieve a 40% reduction in traditional life cycle maintenance costs.

Training

The LPD 17 Class will employ a blend of training capabilities utilizing the latest in cost effective, state-of-the-art training technologies as well as take advantage of existing training programs. Training capabilities will span the spectrum from individually focused tasks, through sub-teams, to fully integrated team training. This training will support all aspects of the shipboard environment with heavy emphasis on tactics, combat systems, and propulsion/engineering systems. Enabling technologies will include traditional systems, simple to highly complex simulation and stimulation techniques, evolving into immersion in synthetic environments that are seamless with respect to operation of shipboard systems such as the Battle Force Tactical Trainer (BFTT) and the Joint Tactical Combat Training System (JTCTS). With a focus on reduced manning and improving readiness, the following advanced training technologies are envisioned: Authoring Instructional Materials (AIM), Computer Improved Instructor Training Aide (CIITA) and other evolving instructor tools, Distributed Interactive Simulation (DIS), Interactive Electronic Technical Manuals (IETM), Interactive Courseware/Computer Based Training (ICW/CBT), Distance Learning and the Electronic Classroom VTC (video teleconferencing), and Training Effectiveness Evaluation (TEE) methods to continuously monitor and improve training

capabilities. This all may sound like we are over reaching technology until you realize that the sailors who will make the LPD 17's first deployment entered the first grade in 1992 , and have never known a schoolhouse without microprocessors or a family room without SEGA!

A primary design driver for future combatants is the requirement that the platform be flexible enough to cope with a variety of roles and missions with vastly reduced manning. From a human performance standpoint, this means that shipboard personnel must be able to adapt their knowledge and skills to address changing mission demands in a rapid and "seamless" manner. This requires preparation levels that exceed those typically demanded under more static conditions, and training systems that offer a complementary degree of flexibility. In particular, it should be possible for shipboard personnel to adapt shipboard training systems quickly and easily to meet current needs. This includes (but is not limited to) the following capabilities: On-demand training--training that can be tailored to meet current performance deficiencies at the discretion of the Commanding Officer (CO) or other team leaders. Such capability puts control of training in the hands of the CO and his/her crew. However, this requires that appropriate mechanisms and tools (e.g., performance measurement techniques, training for shipboard instructors, instructional strategies, debrief guidelines, etc.) are in place. Just-in-time training--advanced skill/knowledge training that can be designed to address specific situational/environmental needs (e.g, operations in the Persian Gulf) -- conducted immediately prior to the engagement. For this capability to be realized, it must be possible for shipboard personnel to easily develop/adapt scenarios, measures of effectiveness (MOEs) and training strategies as necessary.

Mission rehearsal is the most specific form of training that enables operators to practice an actual evolution prior to conducting it. With this capability, the problems of skill decay become less debilitating because personnel can practice crucial skills immediately prior to the operational need. However, the use of mission rehearsal to remediate basic skills is not appropriate. Other forms of refresher training are needed to maintain basic knowledge and skill.

Distance learning provides training to crew members via video teleconferencing (or similar technology) that is conducted at a centralized location and broadcast to a host of learning sites (i.e., ships). While the possible types of training that can be accomplished in this manner are vast, it is not well suited for complex tasks that require extensive hands-on practice. Research is needed to determine which types of knowledge and skills are best trained in this manner. The application of this technology to future ships has the potential to save travel and infrastructure costs currently associated with shore-based training.

Continuous Learning Systems refers to a training philosophy whereby all evolution's are treated as a training opportunity. To accomplish this, performance goals must be set prior to the start of an evolution (e.g., unrep, navigating in restricted waters), performance data must be collected relative to the goal, and specific feedback must be provided at the conclusion of the evolution. In this manner, the evolution itself has learning value as performance is expected to improve in subsequent evolution's. One way to accomplish continuous learning is to develop operational systems that can collect performance data and provide feedback to operators on a continual basis. For example, by tracking keystrokes, it may be possible to improve knowledge of "buttonology" by providing operators with feedback on their performance.

Job/Training Aids. A number of technologies are becoming available that can serve both as training aids and also as job aids. For example, electronic technical manuals and tac memos may be used as a basis for training or as an "on-line" aid during performance. In addition, a technique called "augmented" or "enhanced" reality is being developed for use in the commercial sector. Briefly, the goal is to provide a head-mounted display surface on which information can be presented to an operator in training or during an actual evolution (e.g., a schematic for a computer that is being repaired). The information presented in this manner may serve several purposes: as a memory aid; to provide amplifying schematics or graphics; to present pertinent data, facts, or information; and/or to provide feedback, hints or cues).

Distributed/Joint Training. The advent of distributed interactive simulation (DIS) has

provided an opportunity for distributed training to occur. The potential uses and application of this technology are vast (e.g., battle group, battle force, joint, etc.). However, to be most effective, attention must be devoted to developing the human performance technologies associated with DIS (e.g., exercise design guidelines, performance measurement techniques debrief mechanisms, etc.). Currently, programs including BFTT and JTCTS are developing technologies that will contribute to our ability to conduct viable multi-platform and joint training.

Virtual Reality. Current investment into the Virtual Environment Technologies for Training project (sponsored by ONR; conducted by NAWCTSD) and other efforts provide a strong basis to predict that virtual technologies will be a viable alternative for providing training on later ships of the LPD 17 Class. Continued behavioral research is needed to support development of this capability.

Multi-media training. Current technology affords the opportunity to provide multi-media training for many learning tasks. However, research into cognitive functioning and human learning suggest that initial encoding and subsequent retrieval of knowledge in decision making situations may be fostered (or hindered) by the manner in which information is presented initially. Therefore, effort is currently underway at NAWCTSD to investigate the appropriate application of video, graphics, text, simulation, and animation to optimize retention and availability of knowledge (particularly under stressful conditions).

Conclusion

In order to produce the ships which will constitute our 21st Century Navy, we have a very clear challenge. We must find ways to build and field ships much more cheaply than ever before. The savings must be LARGE. The savings must begin NOW.

The savings must be generated within existing budget levels. Lastly, the savings must occur in both the acquisition and life cycle. Since amphibious shipbuilding programs receive very little upfront R&D, these savings must arise from maximum leveraging of both the R&D and SCN funded design phases of the program. This has compelled TEAM 17 to reengineer the process.

Design for Ownership is a logical extension of the computer aided engineering tools that enabled the Design for Construction paradigm of the past ten years. The aerospace and electrical power generation industries have already made this transition, halving cycle times and costs in may aspects of their industries. TEAM 17's approach is a logical, methodical sequence of reengineering traditional processes, leveraging viable, state-of-the-market information technology, and making room on the design bench for early, direct and sustained participation by the operator, maintainer and trainer.

The technology by which LPD 17 will be produced and deployed will continue to outpace our ability to adapt to it at an ever increasing pace. Consequently, TEAM 17 must strike a balance between the cutting edge and the bleeding edge of this technology. To achieve this balance, we are committed to managing measured risk, learning as we go. It is helpful to remember that the young sailors who will bring LPD 17 to life were born to this technology.

Acknowledgments

We gratefully acknowledge TEAM 17 for providing valuable information used in the development of this paper.

Captain Maurice A. Gauthier *is a native of Salem, Massachusetts, and a 1969 graduate of the Naval Academy and a 1976 graduate of the Naval Postgraduate School. After serving three tours in destroyers, he transferred to the restricted line in the summer of 1979. His qualifying Engineering Duty Officer assignment was Assistant Repair Officer, SUPSHIP Seattle. From 1980 to 1982 he was assigned as the Resident Supervisor of Shipbuilding, Tacoma WA, overseeing the construction of ships for four U.S. Navy program offices.*

From 1982 - 1984, Captain Gauthier was assigned to the Naval Academy as an instructor in the Weapons Systems Engineering Department and Executive Assistant to the Department Chairman.

Captain Gauthier reported to Washington, D.C. for duty in the AEGIS Program Office in the summer of 1984. He was assigned to the AEGIS cruiser shipbuilding office. From 1984 to 1988, he served successively as the AEGIS cruiser post-delivery manager, the AEGIS cruiser production officer, the executive director and the deputy to the AEGIS cruiser program manager.

Upon completion of the Program Manager's Course at DSMC, Captain Gauthier was assigned to the Office of the Assistant Secretary of the Navy (Shipbuilding and Logistics) as the Assistant Director for Shipbuilding and the Deputy to the Director of Ship programs. In March 1988, he became the Director for Surface Combatant Ships in the Office of the Assistant Secretary of the Navy (Research, Development and Acquisition). In January of 1990, Captain Gauthier reported to the Commander, Naval Sea Systems Command as his Executive Assistant and served as such until the Commander's retirement in April of that year. Following that assignment, Captain Gauthier reported to the Direct Reporting Program Manager of the AEGIS Shipbuilding Program as the Chief of Staff where he served until March of 1993. In June of 1993, he assumed the duties as the Security Assistance Program Manager of the Naval Sea Systems Command, PMS 380. In October of 1994, Captain Gauthier assumed the duties as the LPD 17 Amphibious Transport Dock Ship Program Manager.

Captain Gauthier's personal awards include the Legion of Merit with two gold stars in lieu of second and third awards, the Meritorious Service Medal with gold star in lieu of second award, the Navy Commendation Medal and the Navy Achievement Medal. Captain Gauthier is married to CAPT (SEL) Sandi Yates, and they currently reside in Falls Church, VA.

Ms Connie Gragan Clavier *is the Director of Logistics and Configuration Management for the LPD 17 Program.*

Ms Clavier began her career as a Cooperative Education student at the Naval Ordnance Station, Indian Head, MD in 1973. Ms Clavier has held logistic management positions for Ships, Combat Systems and various equipment's as part of an In Service Engineering Activity (ISEA), in the Ships Logistic Manager (SLM) office for Cruisers and Destroyers Type Desk, in the Ship Acquisition Program Management (SHAPM) office for Mine Countermeasure ships, as well as within the Combat Systems Directorate for Surface, Air and Undersea Warfare systems.

Ms Clavier has previously written technical papers on GFE Provisioning Streamlining and on Logistic Support Interfaces with Engineering and Reliability Data.

Ms Clavier is a certified logistician for all levels of acquisition. She has been trained in Defense Acquisition, Configuration Management, Technical Data, Logistic Support Analyses, Maintenance planning, Reliability and Maintainability, Manpower and Personnel, Provisioning and Training. Ms Clavier is a certified Maintenance Planner as well as a certified Missile Propulsion Maintenance technician. She has completed training in Leadership and Executive Development for the Navy.

Ms Clavier is a member of ASE, ASNE and SOLE. She lives in Southern Maryland and is an active member of her community and in local and state organizations.

IMPLEMENTATION OF ACQUISITION REFORM INITIATIVES DERIVED FROM THE OVERSIGHT AND REVIEW AND THE AUTOMATED ACQUISITION INFORMATION PROCESS ACTION TEAMS

Mario Miranda
Assigned to PMA 276
Naval Sea Systems Command (SEA 09Y)

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The views expressed herein are the personal opinions of the author and are not necessarily the official views of the Department of Defense or the Naval Sea Systems Command.

ABSTRACT

"This never amounts to anything" and "this too shall pass" are two common expressions heard when change is occurring. Since early 1994, those of us in the Department of Defense, especially in the acquisition arena, have constantly heard that we must "change the way we do business." Although often such change occurs without careful planning, or is "here today, gone tomorrow", the current acquisition reform initiatives do not appear to bear that resemblance.

Many of us are quite aware of the deletion of numerous military specifications and standards as a result of the "Blueprint For Change" from the Process Action Team on Military Specifications and Standards. You may also be aware of the Federal Acquisition Streamlining Act of 1994 that was signed into law in October of that year and affects over 225 laws pertaining to the acquisition process. You may also be aware of the rewrite of DoD Directive 5000.1 and DoD Instruction 5000.2 which is to streamline the acquisition procedures within DoD. You may not however be aware of the rewrite of several Federal Acquisition Regulations and associated Defense Federal Acquisition Regulations. You may also not be aware of several Process Action Teams (PAT) that have resulted from the "Acquisition Reform: A Mandate for Change" vision of Defense Secretary Perry, such as the Contract Administration, Procurement Process, Electronic Commerce/Electronic Data Interchange, to name a few. This paper will concentrate on specific recommendations of two other of these PATs, the Oversight and Review (O&R) and the Automated Acquisition Information (AAI) PATs.

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Notations/Definitions/Abbreviations

AAI	Automated Acquisition Information
A&T	Acquisition and Technology
ACAT	Acquisition Category
AFAM	Air Force Acquisition Model
AIS	Automated Information System
APB	Acquisition Program Baseline
API	Acquisition Program Integration
APSR	Acquisition Program Status Reporting
CARS	Consolidated Acquisition Reporting System
CAT	Critical Action Team
CIM	Corporate Information Management
DAE	Defense Acquisition Executive
DAES	Defense Acquisition Executive Summary
DFAR	Defense Federal Acquisition Regulation
FAR	Federal Acquisition Regulation
JFT	Joint Functional Team
JPO	Joint Program Office
MOA	Memorandum of Agreement
OAIS	Oversight Automated Information System
O&R	Oversight and Review
OIPT	Overarching Integrated Product Team
OSD	Office of the Secretary of Defense
PAT	Process Action Team
PEO	Program Executive Office
PM	Program Manager
PPO	Provisional Program Office

SAE Service Acquisition Executive
SAM CIM Systems Acquisition Management Corporate Information Management
SAR Selected Acquisition Report
SOC Sets of Capabilities
UCR Unit Cost Report

BACKGROUND

In February 1994, the vision of acquisition reform was presented by the Secretary of Defense in *"Acquisition Reform: A Mandate for Change."* This vision led to the formation of several Process Action Teams (PAT) that were " ... to address each of these and the many other issues which will require attention as the acquisition process is fundamentally restructured"[1] within the Department of Defense. Many of these issues dealt with the acquisition practices within the Department, but others pertained to the manner in which the Department deals with its suppliers.

One of the PATs chartered to study some of the issues from the *"Mandate for Change"* was the Oversight and Review PAT. As a result of recommendations from the O&R PAT, the Automated Acquisition Information PAT was then chartered to study and define specific implementation plans for some of the O&R PAT recommendations.

The Secretary of Defense chartered the O&R PAT to " ... develop within 90 days, a comprehensive plan to reengineer the oversight and review process for systems acquisition, in both the Components and OSD, to make it more effective and efficient, while maintaining an appropriate level of oversight."[2]

Ensuring "... that reporting requirements, when necessary to ensure compliance with policy, include requirements for data that already exists and can be collected without undue additional administrative burdens to the maximum extent practicable..."[3] is one of the primary issues addressed by the O&R PAT that led to the formation of the AAI PAT.

The remainder of this paper will concentrate on the recommendations of the Oversight and Review (O&R) and the Automated Acquisition Information (AAI) PATs as they relate to the Defense Acquisition Deskbook and to the "information net"/Acquisition Program Status Reporting System. The Deskbook is now being fielded by a joint program office at Wright Patterson Air Force Base (WPAFB) and reports to the Director, Acquisition Program Integration (API) of the Office of the Under Secretary of Defense (Acquisition and Technology) (OUSD(A&T)). The "information net" effort was encompassed as the primary effort of the provisional Systems Acquisition Management Corporate Information Management (SAM CIM) program office under the tutelage of the Director, API. The SAM CIM effort recently on 29 February 1996.

PROCESS ACTION TEAMS

OVERSIGHT & REVIEW

The Oversight and Review PAT considered the impact of the oversight process and the milestone decision process (known as the review process) on the workload of program managers, specifically ACAT I programs. The following are excerpts of the goals provided by the Secretary of Defense in his charter for the PAT[4]:

- Determine the level of oversight and review necessary to ensure efficient and effective acquisition programs ...
- Ensure that program oversight and review add value to the particular acquisition program ...
- Ensure that the requirements necessary to conduct efficient and effective program oversight use, to the maximum extent possible, data that program offices already collect. Other data should place the lowest administrative burdens on the program office.

In support of the third goal above, the PAT addressed the oversight reporting process and found that all of the reporting requirements imposed upon program managers, (these reporting requirements include statutory, regulatory, component specific, audits, inspections, etc.) have structured formal reports, contain information available on various media and contain "lag time."[5] As a result the PAT recommended that:

> "... the DAE adopt a new, more continuous oversight process that relies on an electronic information net, face-to-face communications with the program manager and the decision makers, a Monthly Status Report and the statutory documentation as primary sources for oversight information ... "[6]

The "information net" recommendation of the PAT reflects a desire to take advantage of the continuous advances in the area of information technology. The goal would be that decision makers, at all levels of the

acquisition community, and their staffs would have ready access to the most current status of a particular acquisition program.

AUTOMATED ACQUISITION INFORMATION

The Automated Acquisition Information PAT commenced on January 17, 1995. This PAT was chartered by the Under Secretary of Defense (Acquisition & Technology) (USD(A&T)) to:

- Define a vision for a DoD Automated Acquisition Information concept and process, that could be incorporated into the developing Systems Acquisition Management Corporate Information Management efforts.
- Define the process by which acquisition tools, information, policy and guidance needed by OSD, Services and Program Managers are identified and shared throughout DoD.
- Develop a roadmap to implement and institutionalize an Automated Acquisition Information concept and process for DoD.

GOALS OF THE AAI PAT

The AAI PAT then identified four problems and associated goals that they addressed[7]:

Problem: *Distribution of Acquisition policy and approved practices can take weeks or even months to reach the members of the acquisition workforce. Also, no fast path exists to share "good ideas" across the Components.*
Goal 1: An automated acquisition information process will exist that provides timely and effective sharing of information.

Problem: *Program Managers spend significant amounts of time and resources to generate oversight reports. Responsible decision makers do not always have access to the most current information.*
Goal 2: A streamlined automated tracking, monitoring and reporting information process, which integrates with program management planning and execution tools, will be in place and operating.

Problem: *There is no centralized list of acquisition management tools. No procedure exists by which acquisition managers can investigate the existence of a software tool to meet their needs before developing their own. As a result, acquisition managers devote a significant amount of time and money each year to the development of automated tools that already exist.*
Goal 3: A "library" (e.g., inventory, index, catalog) of automated acquisition tools and information will exist and be accessible to all.

Problem: *Acquisition workforce training does not address the use of many tools in the normal curriculum. Those tools that exist are not widely publicized to the acquisition workforce.*
Goal 4: Training and support on AAI systems will be fully institutionalized.

Note the above problem associated with goal 2 is a direct result of the information net recommendation of the O&R PAT.

RECOMMENDATIONS OF THE AAI PAT

To address the first three problems and goals, the AAI PAT recommended the establishment of an automated Acquisition Deskbook and an Automated Program Status Reporting System.

The concept of an Acquisition Deskbook is to centralize and automate acquisition information for the acquisition community. The Deskbook is to consist of a Reference Set, a Tool Catalog and an electronic Acquisition Management Forum. The AAI PAT recommended a Joint Program Office (JPO) be established to manage the daily operations of the Deskbook. It was also recommended that the structure of the Air Force Acquisition Management (AFAM) concept be used to establish the Deskbook structure, thus Wright Patterson Air Force Base would host the JPO and an Air Force colonel would be the initial program manager. Coordination of the contents of the Deskbook was recommended be performed by a joint Service/agency group to ensure relevancy to all DoD Components. This group is known as the Joint Functional Team (JFT) and was recommended to be chaired by the Director, API.

The Deskbook is to be comprised of three portions:
1. A Reference Set which is to
   - act as a bridge between policy and procedures
   - provide a common structure and a means to capture and distribute information.
2. A Software Tools Catalog
   - which is to provide information on acquisition/program management-related software tools thereby gaining greater returns from investment in tools and reducing duplication of efforts.
3. AM Forum which is to provide:
   - timely communication via world wide web

- a bulletin board for exchange of ideas
- an organizational vertical and horizontal exchange on the latest policy initiatives
- a starting point for acquisition information.

The concept of an Acquisition Program Status Reporting System is the continuation of the "information net" recommended by the O&R PAT. The initial effort for implementation is to identify those data elements required for oversight reporting (based upon those data elements that program managers use to manage their programs) and to leverage current technology so the system can access and retrieve these data elements from their physical locations (presumably from the databases of program management offices). These data elements would then establish the system's database which can then be used to accommodate the oversight reporting process. The objective of the concept is that this database will support future automated program management tools and would replace the current DAES reporting process.

The PAT recommended the Department organize a Critical Action Team (CAT) whose objective would be to identify what information is required for reporting purposes and to provide a "data dictionary" describing the information so as to establish the system's database. It was recommended that this data dictionary be completed within 60 days. Once the initial data dictionary was approved, it was recommended that the database be developed with an initial demonstration after only 120 days. This needless to say was a very aggressive schedule.

The AAI PAT Report does however document a difference of opinion on the implementation methodology of this CAT. Some members of the PAT felt that rather than organize another working group, that the data dictionary generation effort is of the cognizance of the Systems Acquisition Management (SAM) portion of DoD's Corporate Information Management (CIM) initiatives. The CIM process is the Department's initiative for Business Process Reengineering (BPR). The CIM process relies heavily on data and process modeling so as to understand the particular functions being performed and the reasoning for performing those functions. The data modeling is to standardize the data elements that support the functional processes. As part of this CIM process, surveys of existing Automated Information Systems (AIS) are performed to identify potential AISs that can support the reengineered functional process. These existing systems are referred to as "legacy" systems. Upon surveying and evaluating these legacy systems, one or more systems are identified for future application to support the reengineered process, therefore known as the "migration" system(s). The objective behind the surveys and evaluations is that once a migration system is selected, the other systems identified during the surveys are no longer funded. These dollars that would have funded these systems are then available to enhance the migration system for implementation across the Department. This process is inherently structured and considerably time consuming. (Note the CIM initiative has been active for six years with migration systems just now being selected, most notably in the procurement arena.) It is because of the time involved in executing the CIM process that the AAI PAT recommended the formation of the APSR CAT.

Defense Acquisition Deskbook

JOINT PROGRAM OFFICE

Included in the AAI PAT Report was a proposed memorandum of agreement for signature by the Deputy Under Secretary of Defense (Acquisition Reform (DUSD(AR)), Director, API, each of the Service Acquisition Executives (SAEs) and the Defense Acquisition Executive (DAE) who is the USD(A&T). This MOA identified the resources required to establish and sustain the Deskbook Joint Program Office (JPO). Each Service, in addition to funding, was to provide three individuals to the JPO located at WPAFB, the same location as AFAM upon whose architecture the Deskbook is structured. Soon after the decision briefing to the DAE/SAEs, the MOA went into the coordination and negotiation process. There were concerns with the funding allocations in the MOA and the relocation of personnel to WPAFB. There was a desire for the personnel to be located at their "home" location and to be electronically linked to the Deskbook. The funding issue was resolved and the personnel location issue was left as an item to be studied. The MOA was signed by the USD(A&T) on 13 July 1995. This automated system is now known as the Defense Acquisition Deskbook (per the 21 February 1996 version of the Draft DoDI 5000.2).

JOINT FUNCTIONAL TEAM

With the MOA came the establishment of the Joint Functional Team that is to act as a joint Service review and guidance group for the contents and operations of the Deskbook. Since the MOA was signed, the DUSD(AR) is now co-chair of the JFT

along with the Director(API). The following organizations are now considered members:

- Air Force
- Army
- Department of the Navy (including the Marine Corps)
- Defense Logistics Agency
- Special Operations Command
- Defense Systems Management College (Executive Secretariat)
- OIPT Leaders (three total)
- Deskbook Program Manager (Technical Consultant).

The three OIPT Leaders were added after signature of the MOA. The AAI PAT Report described the Joint Functional Team as comprising of GS-15 or Service 0-6 equivalents. The three Services expressed their support of the Deskbook by naming high level Senior Executive Service (SES) officials members: Deputy Assistant Secretary of the Army (Procurement); Assistant Secretary of the Air Force (Acquisition); and Assistant Secretary of the Navy (Research Development & Acquisition/Acquisition Reform). To date the JFT has resolved the MOA's personnel staffing issue of the JPO and has determined the contents of the inaugural debut of the Deskbook.

The current plan is for the Army and Navy military personnel, one from each Service, to be electronically linked to the JPO, with work areas in both the JPO and in the DC area. Additionally, the Army and Navy will each provide two civilian billets to be filled by the JPO and located at WPAFB.

CURRENT AND FUTURE PLANS OF THE DESKBOOK

The debut of the Deskbook is to be in March 1996. The Deskbook is to be distributed via CD ROM. The initial distribution will contain:
- the newly released version of the rewrite of DoDI 5000.1 and DoDD 5000.2
- link to the FAR/DFARs
- limited examples of acquisition wisdom and
- an initial yet limited software tool catalog.

Future plans are for the Deskbook to be accessible via Internet, sometime before the end of the calendar year. The Deskbook will continue to be available on CD ROM for the foreseeable future.

Future contents include more DoD Level information, Services and Agency information and more "procurement wisdom", i.e., lessons learned for applicability to the acquisition community. In order to include additional items into the Deskbook, each Service is to generate an evaluation mechanism for prior to implementation into the Deskbook. The JFT will perform a similar function for DoD-wide applications.

It was envisioned by the PAT that the Reference Set portion of the Deskbook would include acquisition information from three categories:

- Guiding Principles - This includes policies and directives that are mandatory for the acquisition process.
- Mandatory-Discretionary - Information relating to products or processes that may be utilized by members of the acquisition community, specifically program managers. (This category was referred to as Institutionalized Knowledge in the AAI PAT Report but was modified during the implementation process.)
- Sage Information - This includes lessons learned, advice from various acquisition experts and general acquisition information that is not included in the above two categories.

The Tool Catalog of the Deskbook is a compilation of information about various software tools available for use by the acquisition community. This catalog would include points of contact, a description of the tool's capabilities, and a functional description with implementation requirements including cost. It is also envisioned that a limited assessment of the tool is also to be provided but simply for "window-shopping" purposes (e.g., description, hardware requirements, point of contact, etc.).

The Acquisition Management Forum is to be an electronic bulletin board to exchange information on various topics such as acquisition reform initiatives, new acquisition practices, upcoming events, etc.

A fourth component has been added to the Deskbook, Procurement Wisdom. This component, derived from the Procurement Process PAT, is to collect and share procurement/contracting lessons learned and experience for the DoD procurement community.

It should be understood that the Defense Acquisition Deskbook is not a replacement for training but supplements training efforts by providing a centralized information source. It also is not a decision making tool but a tool to aide program managers in making informed decisions. It is not a document generator but will contain information about tools to support generating selected documents.

The Deskbook software is also designed to allow future links to other tools. Also, since the Deskbook will only include information considered appropriate by the Services or the JFT members (for DoD-wide dissemination), the system will not become a data dumpsite.

SAM CIM

ESTABLISHING PROVISIONAL SAM CIM EFFORT

After review and coordination of the recommendations of the O&R PAT, the USD(A&T), issued *"Reengineering the Acquisition Oversight and Review Process"* that directed further action of many of the recommendations of the O&R PAT. The objective of the memorandum is to fundamentally change the oversight and review process of acquisition programs throughout the Department.

One of the items in the memorandum dealt with the recommendation of the AAI PAT for establishment of the APSR CAT. The USD(A&T) directed the Principal Deputy Under Secretary of Defense (A&T) (PDUSD (A&T)) to "charter a group as part of the Automated Acquisition Information effort to develop a near-real-time flow of appropriate information to officials requiring program data, including the Program Executive Officers (PEO), Component Acquisition Executives (CAE), and the Defense Acquisition Executive (DAE). The goal of this group shall to be to reengineer the entire acquisition management information and reporting system so that the Program Manager (PM) is not creating data for reporting purposes only, but that the PM is reporting management data that already exists."[8]

Upon coordination and discussions at the directorate and the deputy under secretary level, the Director, API, requested the Services to provide personnel to standup a provisional joint program office to initiate the SAM CIM functional efforts, in lieu of the APSR CAT, but with the primary emphasis to develop the initial requirements of an Automated Oversight Information System (OAIS). In addition, the Provisional Program Office (PPO) was to assess the need for SAM CIM as on ongoing activity, similar to the other functional CIM efforts that are currently underway. The Services provided three personnel for 180 days per the 18 May 1995 memorandum from the Director, API[9]. OSD also supplied two personnel, one from the OUSD(A&T)/API and one from the ODUSD(Acquisition Reform). The Program Manager selected to manage the effort was an Air Force colonel, formerly a program manager of an ACAT IC program. The experience of the PPO personnel consisted of information systems personnel and weapons systems program offices. In establishing the PPO, there was an intent that weapons systems program office experience was necessary to address the sensitivities of program managers.

SAM CIM METHODOLOGY

The Director, API, left the PPO to its own discretion as to the manner in determining the functional requirements of an OAIS. Much of the discussions contained in the O&R and AAI PAT reports, as well as memoranda that addressed the information net, concentrated on the program managers. The prevailing theme from these documents is that information that program managers use to manage their programs should be the basis of the reported data to the oversight community (PEO, SAE and OSD personnel). Internal discussions within the PPO led the members to understand that information needs of the various levels of the acquisition community varied due to functions and objectives. The PPO believed that information that program managers utilize are aggregated at the levels outside the program office. The PEOs perform an assessment of their programs, the Services do the same, and OSD performs the assessment across the Department, especially for regulatory and statutory purposes. The PPO then decided to investigate the type of information being reported and their utility to the acquisition community. The PPO also decided that if an OAIS is to be established for DoD, that the acquisition community should be queried as to their desires and expectations of such a system.

Accordingly, the PDUSD (A&T) requested the Services to identify ACAT ID program offices, PEO and Service personnel (three from each level) that the SAEs desired to participate in the development of an OAIS and to identify the data elements that comprise the database that would support the OAIS. (It was understood by the PPO that any changes to the data currently reported would most probably require additional effort with congressional staff members to modify the statutory requirements.) These participants, whom the PPO considers the coordination network, are listed in Table 1. (ACAT ID programs were selected due to the "attention" they receive from the oversight community and due to the amount and type of oversight reporting required of them.)

The PPO decided to follow the CIM process of surveys, site visits and workshops that utilize Groupware to gather the information from the coordination network as to their needs and expectations of an OAIS.

Prior to beginning the site visits, the PPO generated a definition of oversight to be used throughout the effort. Upon feedback from initial site visits with program offices, the second sentence was added to the definition:

> *The continuing assessment of program planning and execution to provide accurate and timely information on program status relative to statute, the Acquisition Baseline, and pending milestone review criteria. This includes all reports and data provided "up-the-chain" to satisfy statutory, directed or ad hoc information or to seek approval.*

With the guidance provided to the PPO, the following goal was established for the effort:

> *Improve the entire acquisition management information and reporting system so that the PM is not creating data for reporting purposes only, but rather that the PM is reporting management data that already exists.*

In addition to the above goal the following objectives were formulated that the PPO felt any oversight system should achieve[10]:

- Decrease the Program Manager's oversight workload;
- Improve the timeliness and quality of program information provided to decision makers; and
- Leverage technology and existing tools and AISs to improve acquisition information flow.

ESTABLISHING INITIAL FUNCTIONAL REQUIREMENTS OF AN OAIS

Prior to a site visit, surveys were sent in advance to the organization to be visited asking them for the information they report and for the information they require to be reported, based upon their level in the acquisition community. The survey also asked their expectations of an OAIS (e.g., security, accessibility, concerns with an OAIS, etc.) and any particular "business rules" they would require from such a system. These business rules would govern the information flow from, and into, the OAIS. (An example of a business rule is that the information residing in the OAIS will be updated on a determined frequency, for example 45 days.)

LEVEL	DEPT/SERVICE	OFFICE
PMO	NAVY	F-14
PMO	NAVY	AEGIS
PMO	NAVY	F/A-18
PMO	NAVY	NEW ATTACK SUBMARINE
PMO	ARMY	JSTARS
PMO	ARMY	ATACMS-BAT
PMO	ARMY	SADARM
PMO	AIR FORCE	JDAM GBS
PMO	AIR FORCE	F-22
PMO	AIRFORCE	EELV
PMO	AIR FORCE	SBIRS
PEO	NAVY	CRUISE MISSILE
PEO	NAVY	SPACE, COMM, SENSORS
PEO	ARMY	FIELD ARTILLERY
PEO	ARMY	I&EW
PEO	ARMY	TACTICAL MISSILES
PEO	AIR FORCE	CONVENTION-AL STRIKE
PEO	AIR FORCE	TACTICAL & AIRLIFT
SAE/SERVICE	NAVY	DASN/AIR
SAE/SERVICE	NAVY	RD&A/R&E
SAE/SERVICE	ARMY	SARDA
SAE/SERVICE	AIR FORCE	AQXA
SAE/SERVICE	AIR FORCE	AQCS
DAE/OSD	ASD	C3I
DAE/OSD	PAE&E	CAIG
DAE/OSD	A&T	API
DAE/OSD	A&T	S&TS
DAE/OSD	A&T	SPACE
DAE/OSD	DOT&E	
DAE/OSD	A&T	ACQ REFORM
DAE/OSD	COMPTROLLER	
DSMC		
DAE/OSD	A&T	D, DP

Table 1: SAM CIM Coordination Network

A total of nine program offices and four PEO offices were visited. Site visits were also held with staffs from each Service and two sessions with various OSD personnel. In addition to the coordination network, the PPO also held "visioning" sessions with the SAEs or their representatives, the three OIPT Chairs and the USD(A&T). These visioning sessions were to

investigate their oversight requirements and their thoughts on the oversight process. Site visits were also conducted with staff of the SAEs and OSD to determine their oversight requirements and needs, especially in terms of the information they require to "keep the boss informed."

The SAEs and OIPT Chairs stated that the information they require is that which their staff requires. They all rely on their staffs to keep them informed and to identify potential issues. One SAE stated that he expects the PEOs to identify issues or areas that he should be aware and holds the PEOs accountable for their programs. The DAE also relies on his staff but stated that he did want the PPO to identify that information that PMs do not use to manage their programs. Subsequently, the oversight staff would be then be asked to justify their need for the information.

The information obtained from the site visits prior to the first workshop served as a baseline for the questions asked of the 40 workshop participants. This is especially true of the data elements as site visits identified Service unique reports. During the workshops the participants used the Groupware tool (an anonymous electronic input tool whereby all participants can view the inputs of all participants).

Key outputs of the workshops are the capabilities desired of an OAIS and an assessment by the participants of the data/information currently being reported.

Through Groupware, the participants identified the capabilities desired of an OAIS. The PPO took all of the inputs and categorized them into 12 Sets of Capabilities (SOCs). These SOCs were reviewed at the second workshop and ranked in order of importance as shown in Table 2. Technical requirements were also provided and again ranked in terms of importance to the participants and provided in Table 3.

During the first workshop, the Director, API, addressed the participants and expressed his thoughts on an OAIS. He said he was not predispositioned that an OAIS was needed. He told the participants that they were to determine the need for an oversight system, and if the answer was one was not needed, so be it. General consensus from the participants was that some automation would be beneficial in terms of information sharing, but that the system should be small with potential for expansion if later desired.

Access Control/Security
Open On-Line Access To Agreed-Upon Information
Link to Source Data Only Once
Provide/Append Comments To Reports/Documents
Near-Real-Time Info Up/Down PM/PEO/SAE/DAE Chain
Retrieve Information
Retrieve Documents
Notify Users Of Messages/Action Pending
Generate Reports
OIPT Documentation Coordination/Communication Tools
Analyze/Assess Tools & Interface w/Other Databases/Tools
Track Suspenses (Action Items)

Table 2: Sets of Capabilities

Network PM/PEO/SAE/DAE/OSD Locations
Handle Unclassified/FOUO Data (Near-term); Classified (Secret - Long-term assuming multi-security available)
Modern Relational Database
Heavy Use of COTS Software and Hardware
Windows® 3.x Compatible
Link to DMS-compliant COTS E-mail products
Link to COTS word processing and spreadsheet products
Appropriate Flexible API
Enhanced Graphics Capability
Enhanced Word Search Capability

Table 3: Technical Requirements

To support the third objective, which is to leverage technology and existing tools and AISs, and to accomplish a portion of the CIM activities, an inventory of oversight-related AISs, fielded and planned, was conducted. This inventory was to identify existing systems that may be able to support the functional requirements and capabilities defined from the workshops, as well as to identify the magnitude of the efforts currently underway. This inventory identified over 1100 systems. These systems for the most part are funded by organizations for specific purposes and needs of the funding organization. Many are duplicative in terms of the information provided with generally no effort to standardize the data (i.e., a data element may be defined differently from one system to the other) and generally fall below the threshold of the Major Automated Information Systems Review Council process. One can see some benefit of the CIM process for identifying duplicative systems if the funding for these systems can be channeled for streamlining of

the information delivery process. The findings of systems reviewed by the PPO are available in the SAM CIM Final Report.

DATA DICTIONARY

The final piece of the OAIS, but also the most controversial, is the data elements that are to reside in the OAIS database. The AAI PAT referred to the definition of the database as the data dictionary. The term data dictionary not only refers to the information that is to be reported for oversight, but also refers to the metadata that provides additional informtation to define the actual data elements, such as supporting views, entity descriptions and atttributes. This is part of the data standardization process used by the CIM activities for consistency of data element definitions across DoD information systems. Through the site visits and review of known reporting requirements, the PPO was able to identify those data elements that are currently being reported on a routine basis. This amounted to some 1400 data elements. Rather than have workshop participants review 1400 data elements, the PPO folded the data elements into 232 subcategories (known as data information elements) that were reviewed at the first workshop. The PPO analyzed and sorted the results to find a demarcation line for a recommended list for removal from the reporting process. The second workshop reviewed the results and performed another ranking. This second session, and site visits with OSD staff inputs, were again analyzed and sorted by the PPO. The sorting placed priority on the voting of the program management office representatives to be consistent with the SAM CIM objectives of reducing program manager's oversight workload and to improve the quality of program information. One of the findings of this process is that "***One or more subgroups of the oversight community have stated a need for every data subcategory reported by PMOs up the PEO/SAE/DAE chain. On the other hand, the PMOs stated they find only slightly more than two-thirds of the subcategories useful in management of their programs.***"[11] The data dictionary submitted contains the 1400 plus data elements currently being reported but is divided into the Oversight Data Set (ODS) and the Acquisition Reform List (ARL). The ODS contains those data information elements the PPO is recommending for retention in the oversight reporting process while the ARL are those recommended for removal. It should be noted the contents of the ARL are based upon the voting and sorting process discussed above and that there are data elements that, upon further review, would more than likely be moved to the ODS. Upon submission of the ARL with the 5 January 1996 Change 1 of the Draft SAM CIM Report, issues quickly arose from the OSD community with the sorting process and for retention of certain data elements. This was expected by the PPO who recommended a coordinated review process begin to resolve these issues. The Director, API, has taken responsibility for this coordination with support from the DUSD(AR) and the JFT.

Now that the initial functional requirements of an OAIS have been identified, the benefits of such a system on the oversight process should be discussed. At the beginning of the effort, the PPO contemplated the magnitude of the oversight process. During the site visits, one of the questions asked on the surveys was the extent of the oversight process on the program management office staff. Program Managers stratified the time spent on functions that they considered oversight. Figure 1 purports that 16% of a program office energy is spent on oversight. Of this 16%, only 4% is spent on the DAES/SAR/APB/UCR process as shown in Figure 2. It is this process which would be most directly affected by an OAIS in the near-term. With these results, especially from a sample size of nine, the PPO contemplated the oversight burden on the program manager specifically and their key personnel. All ACAT ID program offices (24 at the time) were queried, with six responding due to the short turnaround time with the upcoming holidays. With senior program management staff defined as the top 5% of the staff, 34% of their workload is spent on oversight with 7% of that 34% spent on the DAES/SAR/APB/UCR process. (See Figures 3 and 4) One could argue that 34% is significant and that the OAIS would be beneficial for handling the mundane and updated information requests, but the counter argument is that 34% is not an inordinate amount of time for program managers to be interfacing with organizations outside their offices (note the 30% effort associated with the Service Center/PEO portion).

SAM CIM RECOMMENDATION

Taking all this into consideration, the PPO generated three alternatives that they believed could be prototyped in the July 1997 timeframe and one for 1998: 1) CARS Classified; 2) CARS Unclassified; 3) Near-Full System; and 4) Full System. Of these, Alternatives 1 and 3 generated the most interest.

Alternative 1 can be considered the "Do Nothing" alternative as it is the existing Consolidated Acquisition Reporting System (CARS) with the

current, but not necessarily funded, planned upgrades. This alternative consists of:

- Windows compatability
- modern relational database
- an unclassified Defense Message System compliant E-mail system

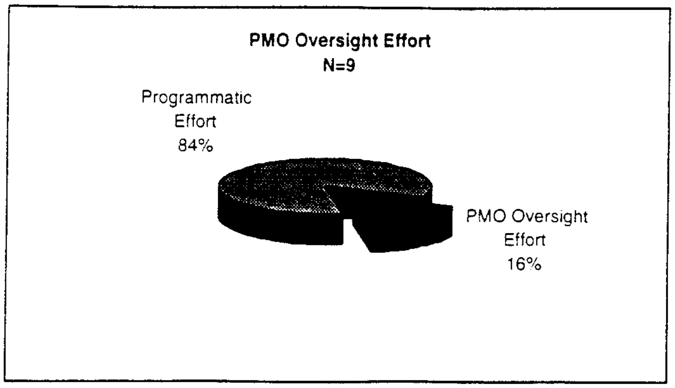

Figure 1: PMO Oversight Effort

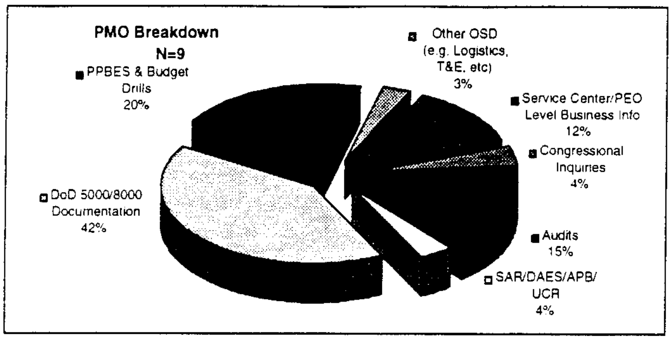

Figure 2: Relative Percentage of Oversight Activity for PMOs

Alternative 3 builds upon Alternative 1 but projects an accelerated upgrade program that consists of two phases:

- Phase 1

- Continue CARS planned upgrades
- Sanitizes the data elements making it an unclassified, For Official Use Only system
- Provide access to an "acquisition library" via the Defense Acquisition Deskbook
- Begin incorporation of the ODS

- Phase 2

- Establish the Army as Executive Agent with support from a joint program office comprised of resources and personnel from the other Services to implement this alternative
- Incorporate those unique Service data elements that are determined to be necessary for oversight
- Establish capabilities of the system to transition to a classified system when economically feasible
- Establish linkage capability to program offices' databases
- Provide Report Generator capability
- Provide feedback capability to PMOs and PEOs on decisions affecting their programs.
- Utilization of the Deskbook JFT to serve as an advisory board for the OAIS.

Alternative 3 was recommended by the PPO based upon an assessment of the alternatives in satisfying the capabilities (SOCs) desired by the coordination network. Also taken into consideration is the ability of Alternative 3 to become an integrated information network across the Department, as envisioned by the O&R PAT. With additional upgrades, the system would be able to interface with other information systems' databases, e.g., test and evaluation and budgetary databases; thus ensuring that program management offices are entering data only once. This would facilitate the ease and timeliness of information across the acquisition community and to others that require the information that resides in the system. Alternative 1, with a modern relational database would facilitate the transfer of data elements into and out of the system, but would inherently not be capable of interfacing other systems and databases and would continue to be a "stovepipe system" only for the SAR/DAES/APB/UCR process that it currently supports.

On 18 January 1996, a status briefing to the DAE and SAEs turned into a decision briefing as the SAE representatives expressed concern over the cost benefits of Alternative 3 (recall Figures 1 through 4) as well as the resources required to staff a new joint program office. One may argue that the sample size of Figures 2 through 5 were minimal, but the Air Force JFT member cited a Rand study conducted for the Air Force of 80 plus program offices that reported similar statistics found by the PPO. It was determined that a CARS Plus acceleration be investigated. The USD(A&T) then requested a roadmap for implementation of this decision.

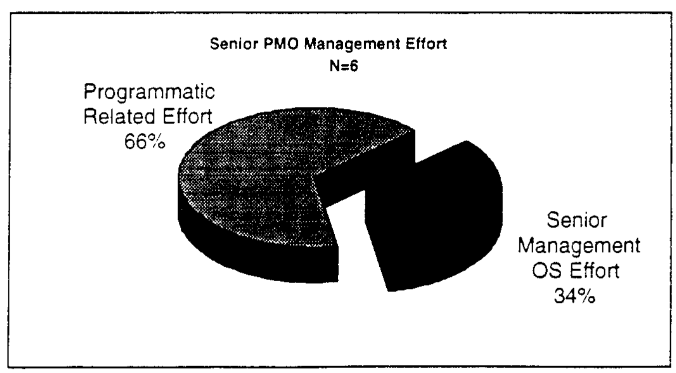

Figure 3: Oversight Effort of PMO Senior Management

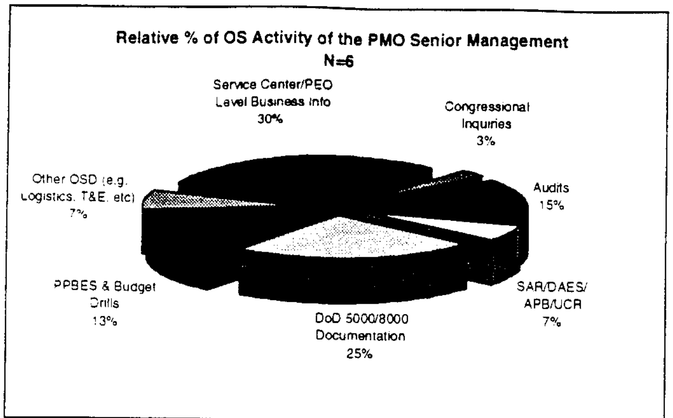

Figure 4: Relative Percentage of Oversight Activity of the PMO Senior Management

This roadmap was the topic of discussion of the Deskbook JFT on 31 January 1996. At that meeting the JFT decided that they are the proper group to provide input for the CARS upgrade roadmap. The group reached consensus that Alternative 1 with additional CARS upgrades as planned by the OUSD(A&T)/API, would be the alternative for implementation. These additional upgrades, although not fully defined at this point, would include the following (as briefed at the 26 February 1996 JFT meeting):

- Network access to the database through Secure Information Processing Routing (SIPRNET)
- DMS compliant Email
- Full Windows capability
- Continuation of the standardization process of the CARS data elements
- Implementation of the Management Reporting tool developed by the Army for executive DAES summaries' generation
- Further development of the integration of the database to support the OSD Executive Information System
- Expansion of the current Error Diagnostics Package for use on all reports supported and generated by CARS
- Internet access from within CARS for those programs using an unclassified CARS to the actual database and
- Capability to access historical CARS reports, APB/UCR/DAES/SAR.

The JFT, still unsure what the CARS Plus alternative truly entails, wanted further definition of these upgrades and a cost/schedule plan for implementation of these upgrades as part of the Roadmap. This CARS Plus Roadmap was briefed to the JFT on 26 February 1996. The plan is to implement a majority of these changes in the next 24 months, pending funding. . After the JFT agrees with the CARS Plus Roadmap and the funding profile, it will be forwarded to the USD(A&T) for his approval. Financing for implementation of the CARS Plus Roadmap is yet to be determined. Past upgrades to CARS have been funded by OUSD(A&T)/API, usually by locating funds at the end of the fiscal year. If there is a capability that is desired in the very near-term, there is some **thought** that the Services may be able to provide some funding, but they have agreed to provide personnel on an ad hoc basis if required. At this time, the Director,API, is responsible for generating the CARS Plus Roadmap as well and its implementation. In addition, the Director, API is responsible for the review and implementation of the ARL.

CONCLUSION

The Defense Acquisition Deskbook and the SAM CIM OAIS efforts are examples of the implementation of a vision derived prior to February 1994. In the case of the Deskbook, it is currently being implemented as a centralized repository for acquisition information. The SAM CIM OAIS effort is proof that the Department is committed to "doing the right thing." Many have a vision of a centralized acquisition program database, but the efforts of the SAM CIM PPO show that the cost benefits are not quite there yet; however, with the size and complexity of the systems the Department procures, such an automated system is needed for more effective management.

These two examples also show the Department's determination to "walk the talk" and not to "just form another committee." The establishment of the Office of the Deputy Under Secretary of Defense (Acquisition Reform) was the initial commitment of Secretary Perry. The office has since, with the cooperation and support of OSD and the Services, performed numerous studies to reengineer the acquisition process through the use of PATs and the implementation of these PATs. The many recommendations of the O&R PAT are currently being tracked by the ODUSD(Acquisition Reform) with a timeline for each.

The Deskbook and the decision on the SAM CIM OAIS recommendation are two examples of the fruits of the Acquisition Reform initiatives and the commitment of the leaders of the acquisition community. The guidance and policy are there to create real change, the leadership is committed, the program offices want it, it's now up to the acquisition community to effect change for the good of our customers, primarily the

warfighters, but also the taxpayers.

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AUTHOR'S BIOGRAPHY

Mario Miranda is a member of Class XIII of the NAVSEA Commander's Development Program. He jsut completed a rotational assignment in the Office of the Deputy Under Secretary of Defense (Acquisition Reform) at the end of February. One of his primary duties was with the SAM CIM Provisional Program Office. He is currently located at PEO(A) PMA-276 working on the USMC H-1 Upgrades Program.

Prior positions include the STANDARD Missile Program Office Production Division (PMS422) and the Product Assurance Division of the Naval Warfare Assessment Division, Corona, CA.

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A STUDY OF INDUSTRY'S IMPLEMENTATION OF TODAY'S MANAGEMENT PHILOSOPHIES & IMPLICATIONS FOR DoD

ROBIN L. FROST
Program Executive Office (Cruise Missiles and Joint Unmanned Aerial Vehicles)

Approved for Public Release
Distribution Unlimited

This paper was written while on assignment as staff to a political appointee in the Office of the Secretary of Defense. The assignment was Special Assistant on the staff of the Honorable R. Noel Longuemare, Principal Deputy Under Secretary of Defense. The opinions expressed in this paper are solely those of the author and are not necessarily the official views of the Department of Defense.

Abstract

This paper examines how industry is dealing with some of today's more popular management initiatives, such as Integrated Process / Product Development (IPPD) and Integrated Process Teams (IPTs), reengineering, empowerment, teaming, etc, and explores the implications for DoD. In each case, parallels are drawn between industry's application of the techniques to (largely) the factory floor and DoD's application to it's workforce. Three companies were chosen for this effort: Frequency Engineering Labs (FEL) Corporation (a small company), Oshkosh Truck (a medium sized company), and Boeing (a large company).

The paper concludes that while DoD can benefit from the application of some of industry's practices, it can never see the dramatic changes that industry has seen as long as decisions are ultimately based on politics, rather than profits. DoD can adopt some of industry's management practices and make the environment more comfortable (for example, by providing more tools, such as training, as opposed to simply signing out directives when changing the way we do business), but the most important lesson we can learn from industry's management practices – *top management's commitment to provide funding to fix problems* – cannot be fully implemented because funding decisions are ultimately <u>not</u> based on economics. Rather, a program's fate is left to the politics on the floor of the House and Senate. For example, the B-2, which has elements of the program located virtually country-wide, survives at the expense of other higher priority programs which need top management's commitment (money), even though the distribution of funds by top management was according to <u>program needs</u>. Or, in another more common but just as troubling scenario, a program runs into problems and money is *taken away from it.* This is done not only by the legislative branch but by the executive branch as well, in part due to the fact that our budgeting process does not provide for reserve funding. In either case, we can never be assured that our senior leadership's commitment can be carried out because sound management decisions can be overridden by other [than economic] considerations.

Another major conclusion in comparing industry's implementation of the latest management initiatives with that of DoD's is that DoD is getting dangerously close to misusing and overusing the reengineering and IPT labels. According to Champy and Hammer, reengineering means completely redefining a process from scratch, without any old rules or boundaries. That is precisely what differentiates it from Total Quality Management, which emphasizes incremental improvements to processes. Based on several examples cited, it appears that DoD may not be implementing reengineering in the way that it was meant to be - ways that industry has found success with. The danger lies in the fact that we risk fooling ourselves that we are deriving the real benefits of the

process - which requires considerable investment of key personnel resources - when we may in fact only be implementing the "buzzword" into our vocabularies. Additionally, it is noted that our zealous use of the IPT label has resulted in the use of the IPT concept to solve almost everything. IPT has taken the place of the word team, and in doing so, has begun to lose the key to its meaning – *integrated process or product.*

Notations/Definitions/Abbreviations

ACTD	Advanced Concept Technology Demonstration
CAD/CAM	Computer Aided Drawing / Computer Aided Manufacturing
DBT	Design/Build Team
DCAS	Defense Contract Administration Service
CATIA	Computer Assisted Three Dimensional Interactive Application
FEL	Frequency Engineering Labs
IPPD	Integrated Product/Process Development
IPT Team	Integrated Product (or Process)
SPC	Statistical Process Control
TQM	Total Quality Management

Three Examples From Industry

Oshkosh Truck

Oshkosh had what seems to be the best example of the true meaning of empowerment, which Oshkosh simply calls "employee involvement". The CEO says that it is a result of what can be labeled as a reengineering initiative, although from the CEO on down, nobody seems to get bogged down with labels or the latest buzzwords that are sweeping the bookstores; they are more interested in simply doing things that make good business sense. In his own words, Mr. Goodson responded to my question about the new management initiatives by saying that he "doesn't get wrapped around the axle"; coming up with new ideas is easy - implementing them is hard. Rather, he is seen as a visionary by his staff, and by his own admission, has an ability to see where things need to go and then lays out the steps to get there. Although his background is teaching systems engineering, he spent time in the automotive industry and credits many of his ideas to what he leaned from Toyota.

Oshkosh is considered a medium-sized company, and currently does approximately 50 percent commercial business and 50 percent military business. At one time or another, they have held contracts with all of the services. Their biggest military customer today is the Army, with the Heavy Expanded Mobility Tactical Truck contract. They also do some Marine Corps work. Some of their current products include aircraft rescue and fire fighting vehicles, snow removal vehicles, and construction and waste removal vehicles.

Oshkosh changed their way of doing business approximately three years ago. Previously, they had "dabbled" with teams, but got serious when they began losing some of the market share and began to see the effects of downsizing in DoD, when their split of military to commercial business dropped from 80/20 to 50/50. Today, they have a Continuous Improvement Manager, who defines their "Employee Involvement and Continuous Improvement" strategic direction as focusing on the development of *people, processes, and products*. But what does this mean exactly? It means that the people on the manufacturing lines take part in major company decisions, interface with suppliers, set their own shift schedules and vacations, manage their own budgets, track their own processes as in or out of control, and set goals to continuously improve the quality of their products.

In the machine shop, where there are union member employees who have been welding for the company for as many as 20 to 30 years, large poster boards display the cost of each machine and its date of purchase. One board has a figure of close to a half of a million dollars for a particular machine. The purpose of these boards is to make the line workers aware of the cost to do business so that they can have a better appreciation of management's concerns with the need to stay competitive. More importantly, however, is the fact that these line workers play a significant role in selecting and purchasing the machinery that they use to do their jobs. The floor employees are

responsible for their own inventory, interface directly with the suppliers and actually do their own orders (as opposed to going through a purchasing department for everything). As a result of these types of changes, one plant manager pointed out where previously he would have had large amounts of sheet steel lying in the yards, but now the line workers order as much as they need for a given period of time and neatly store the steel on shelves that they installed along the walls. In another plant, they were able to get back 60,000 square feet of space (out of 214,000 square feet) that had previously been used for inventory.

Even more striking are the Statistical Process Control (SPC) and budget charts that each team develops and maintains for their portion of the line. The charts show the budget of money that has been allocated to the team to manage, whether they're over or under budget, and whether they are in or out of control on their process. All of this information is produced and maintained by the teams, and made public for customers, management and other teams to see.

The changes were dramatic, and the camaraderie between the line workers and upper management was evident, but Oshkosh is quick to point out that it wasn't easy getting there. One of the lessons learned that DoD can benefit from is that *you need to change the environment and the culture rather than the attitudes* - the attitudes will follow if upper management shows the commitment and provides the tools (training especially).

Oshkosh made quite an effort to change the environment. They downsized by approximately four to five hundred people. They are clear to point out that the reductions were made before many of the major changes were instituted. This provides for a more stable working environment and gives the remaining workforce a real incentive to change -- the same amount of work, but a smaller workforce. Even after a major downsizing (their original workforce numbers were close to 2000), they admit that they have had to eliminate a few people that refused to go with the changes.

In addition to downsizing, they changed their environment in other ways as well. They reorganized and collocated their engineering group with each of their business units. They moved to a teaming environment and replaced their supervisors with team leaders. The replacement was more than just titles -- they went through an interview and selection process to find the right leaders, and hired an outside consultant to "transition their organization." They reduced their number of inspectors to eight, covering 236,000 square feet. They provided tools in the form of extensive training over several years, where every employee was required to take courses in team building, consensus building, leadership skills and SPC. With SPC, they began to "measure the hell out of everything." Metrics are part of their continuous improvement program and they consider them to be "absolutely critical" to do their job. They also provided cross-training for their line workers.

Their biggest barrier in transitioning to the new way of doing business was cited as getting people to genuinely embrace the changes. They noted that some of their good management personnel just couldn't work in teams with the people on the floor. It was top management's commitment that made a difference. An interesting story that their CEO relayed to me that illustrates top management's commitment to employee involvement happened shortly after he took over the helm. A problem was brewing between the first, second and third shifts in the machine shop, which was typical since they usually didn't get along well. The problem snowballed to the point that the CEO had to attend a gathering of the shifts to try to work it out. The problem was so difficult, he couldn't resolve it, and so decided to rely on his line workers to solve the problem on their own. He asked them on the spot if $30,000 would be enough resources to solve the problem - to spend any way they saw fit, no management questions, with one condition - all three shifts had to agree on the solution. The reaction he received was one of disbelief, and the shift representatives even came back to him later to ask if he really meant they could have $30,000 and decide how to spend it. He told them that they already had the money (all the proper signatures had been taken care of), and yes, they could decide how to spend it. After their initial reaction, they went back to the drawing board, came up with a joint solution, but couldn't work it any lower than $43,000. They were asked to present their solution to top management (most of the group had never had the experience of giving presentations, let

alone to top management), and their solution was endorsed. *That* is empowerment.

Another setback they experienced in initiating the changes was middle management's reluctance to "let go" and allow the teams to really make their own decisions. Initially, their machine shop pilot didn't evolve; the teams began making decisions that supervisors normally made, and middle management became increasingly uncomfortable. After two years of training, they "cut the cord," and while they still had skepticism, the situation improved. They found that training was key, and learned that they needed to train middle management to change their "hats" in empowerment to be a supporter versus a director. Today, middle management will sit down and discuss issues with the team leaders that were never discussed three years ago.

Overall, management seems to be happy with their decisions to change the organization. The changes have broken down the walls and have given those who are responsible the authority and resources to do their jobs. As one plant manager stated, "It's no secret, it's our people who are making it happen. It's pride and job security." (As a union company, Oshkosh has even more of an incentive to stay competitive given their higher labor rates.)

As a side note, Oshkosh Truck has had common processes for their military and commercial products since January 1995. On one line, a military vehicle can be seen being manufactured, and right behind it is a commercial vehicle. This enables Oshkosh to keep the line moving even as defense numbers decline. Oshkosh is one of the ten percent of companies who received ISO-9001 certification on the first audit, and the Coopers & Lybrand Report (commissioned by Secretary Perry) noted them as one of the most efficient companies.

The main observation that the CEO had to offer for DoD was that while the higher levels of government seem to be "enlightened" (e.g., risk takers), the lower levels of government seem to be operating according to business as usual. He also offered the following "principles to live by":
Rule #1 - Have a vision with time being the critical parameter (example: X weeks to get an RFP out). Set an impossible goal that "stretches" the organization - this causes everyone to focus on the goal rather than "me."
Rule #2 - No hand-offs. Organize so that no group can be completely devoid of responsibility for a product/project until it is completed.
Rule #3 - When rule #1 and 2 are followed, efficiencies will follow. Cut before implementing changes. If the organization is reduced ahead of time, the remaining people will have incentives to fix it.
Rule #4 - Ensure that everyone is aware of the "external devils" (competition in their case, Congress in ours).

Frequency Engineering Labs (FEL) Corporation

FEL is classified as a small business with under 300 people, and they do approximately 98% defense and 2% commercial business. Currently, the bulk of their business contracts are with the Navy, including the NIXIE SLQ-25A acoustic torpedo decoy system, the Torpedo Defense Controller, which integrates the 25A with other shipboard systems, and satellite communication systems (Tactical Data Information Exchange Subsystems, TADIX). They also participate in the Small Business Innovative Research program for DoD. They have done work for the Army and Air Force, as well as the FAA in the past. Their commercial work currently consists of microwave products, although their biggest commercial customer in the past was IBM, in which they manufactured, assembled and tested CPUs for mainframes.

FEL has embraced a teaming concept in order to deal with today's business climate. They noted however, that while there are a lot of management initiatives out there, each with different names, all have a common theme -- pushing responsibility and decision making to the lowest level. Like Oshkosh, they initiated teaming some time ago (approximately ten years ago), but it didn't really "catch on" until much later (approximately five years ago). While they put out an internal memo that directed that they would operate under a team concept, they also recognized that they could not "wave a wand and say you're empowered." (Does this sound like the DoD Program Managers' Bill of Rights?) Some time ago, they eliminated the job class "inspector" so each individual was responsible

for his or her own inspection, and were written up as a best practice under Willoughby's "Team Q" initiative. They believe that all of their employees realize that management is committed to this change, as evidenced by the fact that the manufacturing personnel will bring problems to their attention, whereas previously they would not have been inclined to do so.

Like Oshkosh, they started out small - their tact was to initiate the concept at their "independent business center," which was established during their work with IBM - the purpose of which was to set up a totally independent group, driven purely by economics versus regulations (like DoD work). They tailored the facility and the staffing to their commercial needs, and got rid of the traditional management role.

Today, FEL operates with task-oriented teams. Their teams are made up of representatives from multiple disciplines, so they could be called IPTs, but like Oshkosh, FEL focuses more on the meaning behind the label than the label itself. They have a bid-process team, a purchasing team, etc, some of which are temporary and some of which are permanent. Like Oshkosh, they focus on team training, and have problem solving and team skill training, as well as in-house facilitators for their teams. They also rely heavily on metrics.

In terms of reengineering, FEL had the best example (in the <u>true</u> sense of the word *reengineering*). They had been doing incremental improvements to their mainframe computer center, when they decided to set up a reengineering team to "reengineer data processing in the company." The reengineering team's solution to the mainframe computer center problem, in the true spirit of reengineering, was to do away with the mainframe computer center, and move to a distributed network environment.

Overall they are happy with their decision to move to a teaming/empowerment environment, but they are quick to admit that it hasn't been a bed of roses getting there. They have seen a difference in quality <u>and</u> productivity, but the biggest barrier they found in moving to this type of environment was "culture shock" - "some folks liked it, some folks didn't." They have found, however, that teams seem to weed out people with "attitude problems." The teams are given objectives on production throughput, quality levels, etc, and they've found that when they have a problem team member, the rest of the team tends to "bring them up" as opposed to pushing them to the side in order to meet their team objectives.

They even experienced culture shock with the customer. Years ago, their DCAS office indicated that they needed a separate quality organization from their manufacturing organization. In order to avoid doubling their costs, FEL chose to put their test group in a quality organization. This was met with some resistance, until finally the DCAS office accepted the move because there was ultimately no rule to enforce it.

FEL has been involved in IPTs with the government, and has had some good and some not so good experiences. They've encountered some problems with reaching consensus, and suggested that DoD needs to employ good facilitators in teaming arrangements, as they do in-house. They also observed that some of the IPTs were limited and didn't have enough technical talent on the teams, so members need to be carefully selected.

Boeing

(<u>*Note*</u>: The following information is from an interview with A. Lee Battershell, Research Fellow, Industrial College of the Armed Forces, and author of "Technology Approach: DoD versus Boeing" {C-17 versus the 777}. Boeing's President, Vice President and General Manager, 777 Division, Senior Vice President, Airplane Development and Definition, and President, Boeing Defense and Space Group, were extensively interviewed along with the Director of Flight Test Engineering and several other Boeing engineers.)

The general observation with the 777 development was that "the new management initiatives influenced the 777 very much." In terms of teaming, Boeing used what they called Design/Build Teams, which is very similar in concept to IPTs. (IPT was not a term in wide spread use at the time.) The Design/Build Team (DBT) concept was first introduced with the limited use of CATIA (Computer Assisted Three-dimensional Interactive Application, similar to

CAD/CAM) on the 767 program. Using DBTs was an evolutionary process for Boeing, and CATIA facilitated it. The primary drivers cited for moving to DBTs were (1) Boeing's President (a "visionary"), and (2) the results of a study which showed the primary cost drivers to be rework on the factory floor.

In the World War II timeframe, Boeing had their designers and manufacturers physically located in the same building to allow them to work problems together. As the firm grew larger and planes became more complex, the designers were separated from the builders both geographically and philosophically. For the 777 effort, however, the designers and manufacturers were linked back together through the use of distributed network technology. Using CATIA, team members would sit around computer screens, view the 777 parts in three-dimension, and talk to eachother via phone. Not only were the designers and builders involved, but the customers as well. In addition, the team included other Boeing employees that would not normally be part of the team, such as finance and airplane maintenance. Philip Condit, Boeing's President, notes that they redesigned Boeing at the same time that they designed the 777. Computer technology advances allowed Boeing to change its culture, improve quality, and cut manufacturing costs.

In terms of organization and streamlining initiatives, Boeing's 777 program manager had only one layer between his level and the top - the commercial division president. With weekly meetings between the PM and top management, it was easy to get the tough decisions made to commit resources. This was seen as a key difference between Boeing and DoD. In DoD's case, the contractor could likely go through the program structure, the command structure, the service staff, the service secretariat, OSD, and finally Congress for the same commitment of resources. However, given the fact that Boeing does not have to divide their attention among a number of major programs as DoD does, this difference is not too unexpected.

Another key difference in management style is Boeing's tendency to be more conservative than DoD in terms of the application of technological breakthroughs. Boeing tends towards technology improvements versus breakthroughs, except where they are protecting their marketshare, such as in engine development. In their own words, technology had to "earn its way" onto an aircraft; in other words, they didn't include more technology than the market would buy. This is a difficult comparison to make, however, due to the fact that DoD doesn't have the luxury to let technology earn its way into the battlefield when the enemy exploits every new technology and our military puts their lives on the line for our freedom. It is a worthwhile comparison, though, because it highlights the fundamental difference between industry and DoD -- industry is motivated by profits and DoD is motivated by politics. As the Director, Defense Procurement pointed out in her comparison of the business practices of Motorola's IRIDIUM System to a DoD Weapon System, the primary difference was attributed to Motorola's role as a private seller in a competitive market place versus DoD's role as a buyer responsible for the stewardship of taxpayers' funds.

Additionally, while DoD has tended to focus only on performance in the past, Boeing focused on performance, *cost and market competition*. With the advent of the CAIV (Cost As an Independent Variable) Initiative, this trend will change (hopefully). However, what will not change is the tendency to take money away from a program, such as the C-17, when it runs into problems (and thereby stretching the schedule out and increasing the likelihood that the fielded technology is obsolete), as opposed to Boeing's throwing resources (money and people) at the 777 when it had schedule problems. In this respect, it is noted that the 777 was completed at approximately the same time as the C-17, even though it was conceived years later.

The biggest difference between DoD and Boeing in the cases of the C-17 and 777, then, was seen as Boeing's commitment to making the program a success, and their flexibility in doing so (without distractions such as color of money, which was seen as a detractor in keeping our energy focused on the main goal - fielding a system). Reference the capital expenditure for the 777 plant. It should be pointed out, however, that Boeing does not face a "Washington Post Test" as DoD does.

Conclusions

Common Themes

The common theme that emerges from the Boeing and Oshkosh interviews is demonstrated commitment by top management to supply resources when they are needed. In Boeing's case, it's the 777, and in Oshkosh Truck's case, it's the machine shop that needed that demonstrated commitment.

A common theme that emerges from the FEL and Oshkosh interviews is the tendency to push responsibility and decision making to the lowest level. Both FEL and Oshkosh have given their manufacturing workers the right to "reach up and pull the cord" or stop the line if something is wrong. This is quite a drastic measure, but they have allowed delegation of that decision to their lowest levels. (Although as Oshkosh Truck's CEO points out, the risk of empowering an employee on the factory floor is considerably lower than that of an employee behind a desk, by virtue of the fact that management can see exactly what everyone is doing on the floor, but it is more difficult when the employee is behind a desk. This may sound less than altruistic, but it is a practical consideration for a CEO.)

A striking similarity between Boeing and Oshkosh was Boeing's President's assertion that he is a big fan of the Japanese TQM/teaming concept, and Oshkosh Truck's CEO's assertion that many of his ideas came from what he learned from Toyota.

Summary

Implications for DoD

While we can change the environment that we operate in (reorganize, use IPTs, etc), and provide more tools to make the environment more comfortable (such as training to go along with directives from the top), the most important thing we can learn from industry, which is the common theme of demonstrated commitment, cannot be fully realized. The primary reason for this stems from the fact that industry is motivated by profit and the government is motivated by politics -- our funding decisions on programs simply are not based on the bottom line (the dollar). Rather, their fate is left to the politics of the floor of the House and Senate. As an example, a program like the B2, which is spread out across the country, survives at the expense of other higher priority programs which are badly in need of top management's commitment (money) to fix their problems. Even when a program survives the conference, it is constantly at risk of having money ***taken away from it*** when it runs into a problem, by either the Legislative or the Executive branch. So while there are benefits to be derived from the implementation of some of industries practices, we would never be able to see the dramatic changes that industry has seen simply because we can never be assured that our top management's commitment can be carried out given that decisions can be overridden by other [than economic] considerations.

It is worth pointing out that it seems to be more than just talk at each of these companies. The management seems to believe in what they are saying, and their stakes are higher than DoD's when the words are put into action. For example, if DoD goes over budget or gets increasingly inefficient, it isn't a foregone conclusion that we will lose our market share and possibly our jobs. Even though it is not as secure as it used to be in the government, it's not on the par of the climate that industry operates in - and they are taking real risks. In this light, DoD's Program Managers' Bill of Rights seems to fall a little short in comparison to the measures taken in these examples from industry in pushing responsibility and decision making to the lowest level.

In terms of teaming, industry's overwhelmingly positive experience can be taken as a lesson learned for DoD to continue in its teaming efforts. In terms of reform, Oshkosh Truck's observation that while the higher levels of government seem to be "enlightened" (e.g., risk takers), the lower levels of government seem to be operating according to business as usual seems to be a valid one. In my own personal experience, I have found that most of the directives, memos and sweeping reforms coming out of OSD rarely find their way down to the engineer on the program. This makes it difficult to discern where DoD stands on matters of important policy.

As a final observation, it was more than noticeable that this sampling of industry didn't seem to be as enamored with labels as we tend to be in DoD. A valid criticism that merits some consideration is DoD's apparent overuse and misuse of the IPT and reengineering terms. The mere fact that we tend to overstuff our vocabularies with labels is of little consequence, until one realizes that we risk fooling ourselves that we are deriving the real benefits of the process - which requires considerable investment of key personnel resources - when we may in fact only be implementing the buzzword into our vocabularies, and in the process, distorting the real meanings. Case in point: In the "Reengineering the Acquisition Oversight Process" effort, many of the actions that resulted were phrased in a manner similar to "improve the timeliness of xyz process." The same can be said about the recent effort to reengineer the DoD Transportation Process. According to Champy and Hammer, reengineering means completely redefining a process from scratch, without any old rules or boundaries. That is what differentiates it from Total Quality Management, which emphasizes incremental improvements to processes.

Our zealous use of the IPT label has resulted in the use of the IPT concept to solve almost everything. IPT has taken the place of the word team, and in doing so, has begun to lose the key to its meaning as well -- *integrated process or product.*

Recommendations

In terms of reengineering, two recommendations are offered. First, it would be wise to make Reengineering the Corporation: A Manifesto for Business Revolution required reading for all reengineering teams in DoD. An alternative to this approach is to develop a course with this widely accepted book as the basis for training. Secondly, in these days of encouraged acquisition reform, we are at a prime point to "throw out old rules" and really try reengineering. A prime candidate seems to be the process by which we get technology to the fleet. This fits the definition of being "reengineerable" in that (1) it is a process, (2) it is a process by which we service our customer (probably the most important), and (3) it is badly in need of repair -- our technology is far ahead of it's time in the lab, and usually obsolete by the time it gets to the fleet. ACTDs, unfortunately, are not the answer -- this needs to be *institutionalized*, not the exception.

Other recommendations include revisiting the DoD Program Managers' Bill of Rights (a question for the applicable Program Managers - are we *really* pushing responsibility down to the lowest level?), continue teaming, use IPTs when it's clearly an integrated process that is necessary, place more emphasis on selecting and screening IPT members, and consider the use of facilitators when IPTs are used.

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Oshkosh Truck
R. Eugene Goodson, Chairman & CEO
Kirsten Skyba, Manager of Marketing Services
Ellen Bestor, Continuous Improvement Manager
Tom Fenner, Plant Manager - North Plant
Mike Wuest, Plant Manager - South Plant

Frequency Engineering Labs Corporation
G. Foster Hirsch, President
Benjamin Amato, Vice President Operations
Horace Leavitt, Jr., Vice President Program Management
Jim Albers, Vice President External Affairs

Boeing
Via A. Lee Battershell, Research Fellow, Industrial College of the Armed Forces, and author, "Technology Approach: DoD versus Boeing", who conducted extensive interviews with:
Philip Condit, President
Dale Hougardy, Vice President and General Manager for the 777 Division
Jerry King, President Boeing Defense and Space Group
Allan Mulally, Senior Vice President Airplane Development and Definition
Jerry Zanatta, Director of Flight Test Engineering
William Savery, Chief Engineering Operations
Ron Ostrowski, Director of Engineering, 777 Division

***Robin L. Frost** attended the Pennsylvania State University and is an alumni of the University of Virginia. Ms. Frost received the President's Freshman Award and the President's Sophomore Sparks Award while at Penn State for maintaining a 4.0 grade point average in engineering, and was a member of the University Scholars of the Pennsylvania State University. At the University of Virginia, Ms. Frost was a distinguished graduate, maintaining a cumulative grade point average of 3.9 and 4.0 in her major, and was a member of the Omega Rho Systems Engineering Honor Society as well as Tau Beta Pi, the National Engineering Honor Society. Ms. Frost has received honorary recognition in the National Dean's List.*

Ms. Frost began her career at the IBM Corporation in Manassas, Virginia, where she became Lead Engineer for the LAMPS MKIII SH-60B Weapons Tactics Trainer / Operational Flight Trainer program for the Navy. At IBM, Ms. Frost attained the Senior Associate Engineer / Scientist level and received the distinguished IBM Special Appreciation Award and an IBM Cash Award for her work on LAMPS MKIII. Ms. Frost spent her final year at IBM in the commercial Systems Integration Division in the banking sector, developing applications and writing and marketing proposals to major banks in the US.

In 1990, Ms. Frost joined the Space and Naval Warfare Systems Command, and became project manager of the Integrated Assessment Environment, an integrated environment of models and simulations to support warfare mission area assessments.

Ms. Frost attended the Defense Systems Management College Program Manager's Course (PMC) in 1991, and went on to join the Program Executive Office for Cruise Missiles and Unmanned Aerial Vehicles (PEO(CU)) as a Supervisory Systems Engineer, serving as division head for the Systems Integration and Requirements Division. She later went on to serve as a systems engineer on the staff of the Deputy PEO.

Ms. Frost's latest assignment was on the staff of the Principal Deputy Under Secretary of Defense (Acquisition & Technology) as a Special Assistant.

Ms. Frost was born in Pittsburgh, Pennsylvania in 1963. She and her husband, Stephen Frost, reside in Arlington, Virginia.

SYSTEM SAFETY LESSONS LEARNED AND THE COMMERCIALIZATION OF NAVY SHIP DESIGN

THOMAS W. COSTANTINO
Human Systems Integration Division
(SEA 03D7)
Naval Sea Systems Command

KENNETH R. POWELL
George G. Sharp, Inc.

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Abstract

Unmitigated design related hazards are a leading cause for the occurrence of incidents resulting in system damage and personnel injury or death. The majority of safety related design criteria contained in current design tools are there as a result of lessons learned from the analysis of past incidents. They have been extracted from analysis of incidents resulting from both battle and self-inflicted casualties. These criteria are often "written in blood", having caused loss of life. Specification of these criteria provides for reductions in incidents, therefore resulting in cost savings over the life cycle of the system. Life cycle savings are manifested in reduced loss of operational availability of the system, reduced loss of life, reduced lost time incidents and reduced safety related repairs and backfits.

In the current environment of commercialization of ship design and during the development of performance based systems specifications, the Naval Sea Systems Command (NAVSEA) must ensure that programmatic lessons-learned from past system safety application to designs are not "lost". Particular attention must be applied by everyone involved during this process to ensure that these programmatic lessons learned, proven to be cost effective, are incorporated into the adoption of commercial specifications and into the evolving performance specifications.

List Of Figures

Definitions/Abbreviations

Safety is defined as "the optimum degree of freedom from mishap attainable, within the constraints of operational effectiveness, time and cost, achieved through specific application of system safety management and engineering principles throughout the life cycle of a system."

System safety management is the principle through which an effective program is developed and maintained which ensures that hazards are identified, and either eliminated or mitigated, early in the design when design changes are most cost effective to accomplish.

System safety engineering is the application of special technical and scientific principles and methodologies to the systematic, forward-looking identification and control of hazards throughout the life cycle of a system. The concept calls for safety analyses and hazard control actions, beginning with the conceptual phase of a system and continuing through the design,

production, testing, use, and disposal phases.

ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
BSD	Ballistic System Division
DDS	Design Data Sheet
GENSAFE	*General Safety Design Criteria for Ships of the United States Navy*
GENSPECS	*General Specifications for Ships of the United States Navy*
MILSPEC	Military Specification
MILSTD	Military Standard
NAVSEA	Naval Sea Systems Command
NAVSEAINST	Naval Sea Systems Command Instruction
NAVSEC	Naval Ship Engineering Center
NAVSHIPS	Naval Ship Systems Command
OPNAV	Office of Chief of Naval Operations
SDS	Ship Design Standard

Introduction To System Safety

Safe system operation is vital in achieving and maintaining operational readiness. A system, regardless of its level of complexity, is usually made up of personnel, procedures, materials, and equipment and their interfaces. When used together these system elements perform or support an operational mission. By maintaining a system safety focus that includes the participation of trained and experienced system safety. engineers in the design and construction of Navy ships, systems and equipment, a high degree of freedom from mishap occurrence can be cost effectively achieved during their life cycle.

The application of system safety improves operational readiness, reduces backfitting delays and costs and provides the Fleet with a safer ship and a healthier shipboard environment in which to live and work.

Occupational Safety and Health and Environmental Safety are subsets of System Safety and must be designed into the system, not added on, to be operationally effective and cost effective.

Designing In Safety

System safety can be effectively obtained within the constraints of mission performance, schedule, and cost. Maximum effectiveness is obtained by applying system safety principles commencing early and continuing throughout the life cycle of the system. By Milestone I, it is estimated that 70% of the cost of building and operating a system has been determined. Early attention to safety engineering considerations reduces later design changes necessary to correct safety deficiencies. Late design changes historically add weight and complexity, decrease reliability, and increase maintenance time. Just as important, late changes have a negative impact on the primary program resources of time and money.

History Of System Safety

In the early days of system safety engineering, safety programs were usually established piecemeal, based on an after-the-fact philosophy of accident prevention. For example, an aviation approach was often called the "fly-fix-fly" approach: build it and fly it; if it doesn't work, fix it and try flying again. When an incident occurred, an investigation was conducted to determine the cause. Accident causes were then reviewed and

discussed to determine what must be done to prevent similar incidents. The resulting system modifications, retrofits, or correction of design safeguards or procedures were made to existing systems. However, corrections to existing designs can be costly and often meet resistance.

The system safety concept evolved, incorporating a planned, disciplined, systematically organized, and before-the-fact process characterized as the identify-analyze-control method of safety. The emphasis was placed upon an acceptable safety level designed into the system prior to actual production or operation of the system. The system safety discipline requires timely identification and evaluation of system hazards during design, before incidents occur. These hazards must be eliminated or controlled to an acceptable level to provide a system that can be developed, tested, operated, and maintained safely.

In September 1947, a paper titled "Engineering for Safety" was presented to the Institute of Aeronautical Sciences. It stated the following: "Safety must be designed and built into airplanes just as are performance, stability, and structural integrity. A safety group must be just as important a part of a manufacturer's organization as a stress, aerodynamics, or a weights group."

That technical paper provided one of the earliest recordings of the system safety concept. It was not until the early 1960s that the concept was applied formally by contractual direction. This formal delegation of safety responsibility by contractual requirement replaced the familiar practice in which each designer, manager, and engineer presumably assumed his share of the responsibility for safety. The growth and development of the system safety approach to accident prevention was created by the publication of safety standards, specifications, and requirements, as well as operating instructions.

In April 1962, the Air Force published BSD Exhibit 62-41, "System Safety Engineering for the Development of Air Force Ballistic Missiles," applicable to Ballistic System Division programs. This document established system safety requirements for the associate contractors on the Minuteman missile program, where the first real system safety groundwork was done. In September 1963, the document was revised into Air Force specification MIL-S-38130, "Military Specification-General Requirement for Safety Engineering of Systems and Associated Subsystems and Equipment." With very minor revision, in June 1966, this specification was made a Department of Defense requirement, MIL-S-38130A. Finally, in July 1969, the specification was revised further and became MIL-STD-882, "System Safety Program for Systems and Associated Subsystems and Equipment: Requirements for." Department of Defense approval of MIL-STD-882 led to the mandate for a system safety program on all procured products and systems.

In a similar manner, the use of system safety programs have grown in commercial industry, as programs pioneered by the military were adopted. An important, and perhaps the most sophisticated, use of system safety methods today is in the nuclear power, refining, and chemical industries. The outline for a system safety program, as detailed in MIL-STD-882, is used by many industries in establishing a corporate system safety program for the products they are developing. Requirements for standards evolving from within the American National Standards Institute (ANSI), American Society of Mechanical Engineers (ASME), and many other

professional societies have culminated in a concerted effort to insure that system safety principles are applied to products used by the public. System Safety has come of age in many venues of commercial design and manufacture. The lessons learned are that system safety pays off in cost effective products, fewer accidents, and a longer product life.

System Safety History In Navy Ship Acquisition

One of the first applications of system safety to a naval ship design came about not because of a deliberate, initial objective of either OPNAV or NAVSEA (then NAVSEC), but rather as a result of the Navy's acceptance of recommendations of a ship design/construction contract. It is historically significant that the contractor was not a traditional old line shipbuilder, but rather was aerospace oriented. The contractor was Litton. The year was 1968. The ship was the LHA 1 Class and was procured under the total package concept wherein the ship specifications were developed by the contractor based on the Navy's performance needs. During specification preparation, a System Safety Program based on the Air Force Specification MIL-S-38130 was proposed and became part of Litton's engineering package. Had the LHA contract gone to a more traditional shipbuilder, it is extremely doubtful that system safety would have made its debut on that ship class.

Within the same timeframe, a parallel course of events was taking place which led to the implementation of system safety in the early design phases of those combatants which were being designed in house by NAVSHIPS. The well publicized aircraft carrier fires on USS ORISKANY, FORRESTAL, and ENTERPRISE cost the Navy over $160 million in damages, over 200 killed and about 700 injured. In the ensuing investigations it was noted that NAVSHIPS had no specific safety office. One was institutionalized in 1968 under NAVSHIPS' technical arm, the Naval Ship Engineering Center, as Code 6105. One of this Center's products was the design of ships from feasibility studies through contract design. The new safety office, armed with the first issue of MIL-STD-882, pushed for the adoption of system safety in two endeavors. The first was the initial design of the Patrol Frigate known as the FFG 7 Class. The other was a new design fast attack submarine, the SSN 688 Class. The submarine had already completed Contract Design and the Detail Design and Construction Contract had been awarded to Newport News Shipbuilding. The proposals to implement system safety in those projects were approved with NAVSEC conducting the Hazard Analyses for the FFG 7 and Newport News Shipbuilding analyzing most of the critical systems in the submarine design. Since that time, system safety has continued to be applied in most of NAVSEA's ship designs.

NAVSEA Ship System Safety Engineering Program

NAVSEAINST 5100.12A - Requirements for Naval Sea Systems Command System Safety Program for Ships, Shipborne Systems and Equipment, dated 11 December 1995, provides the information and guidance necessary to ensure that system safety is performed at the earliest levels of design by all NAVSEA activities. The instruction provides the necessary information on how to tailor a system safety program to fit the project.

NAVSEA 03D7 is currently preparing System Safety Training Courses tailored for management and for engineers and technicians. With these courses and

NAVSEAINST 5100.12A in place, the NAVSEA 03 design community will become a better informed community .

PROGRAM MANAGEMENT AND CONTROL	
Task 102	System Safety Program Plan
Task 106	Hazard Tracking and Risk Resolution
Task 107	System Safety Progress Summary
DESIGN AND INTEGRATION	
Task 202	Preliminary Hazard Analysis
Task 205	System Hazard Analysis
DESIGN EVALUATION	
Task 301	Safety Assessment
Task 303	Safety Review of ECPs, RFWs, RFDs, and RCIAs
COMPLIANCE AND VERIFICATION	
Task 401	Safety Verification

Figure 1. Minimum Tasks for Ship Acquisition System Safety Program

The system safety process mandated by NAVSEAINST 5100.12A is based on the requirements of MIL-STD-882, which provides uniform requirements for developing and implementing a system safety program comprehensive enough to identify the inherent hazards. The revised NAVSEAINST 5100.12A requires the inherent safety of a ship design to be optimized utilizing the concepts and techniques of system safety as set forth in MIL-STD-882, System Safety Program Requirements. Most ship system safety programs should contain the MIL-STD-882 tasks in Figure 1. as a minimum.

It is a goal of the ship acquisition programs to provide reasonable assurance that no identifiable hazards will exist within the system which could be expected to result in major system damage or serious personnel injury. Any such hazards inherent in the evolving design shall be identified through the application of hazard analyses and eliminated or controlled.

System Safety Program Lessons Learned

During the evolution of system safety as an engineering discipline, a number of lessons were learned about system safety engineering and its application to systems design. Only a few of the more significant lessons learned will be addressed here.

The numbering of the lessons learned is incidental and not an indication of the relative level of importance.

Lesson learned number one is that inclusion of system safety engineering in a system design is value engineering. The relatively low cost of inclusion of system safety in a design process results in an on-line system with significantly lower system damage or loss and significantly lower incidence of injury or death to personnel, resulting in significantly higher operational availability of the system and the operators. **System Safety engineering applied to a system design results in significant life cycle cost savings.**

Lesson learned number two is that a system, once designed and verified as being a safe system, and used as intended, will remain a safe system without further system safety involvement until such time

as changes are made to the system design. Without system safety included as a consideration in their evolution, system design changes can result in the elimination of inherent safety criteria (features) and in the introduction of new hazards into the system. **System safety engineering must be applied to design changes.**

Lesson learned number three is that historical data, relative to safety incidents on existing systems, are a remarkably accurate indicator of safety design deficiencies in the system. Analysis of this data can result in development of system safety design criteria applicable to follow on design for acquisition of like systems. **Historical safety incident data must be reviewed for applicability to new acquisitions by all levels of acquisition and design teams <u>and</u> by the contractor responsible for detail design and construction.**

Lesson learned number four is that new technology brings new and previously unknown system and operating environment hazards. The evolution of new technology brings with it no knowledge of or history of past safety incidents upon which to base preliminary and system hazard analyses. The minimum tasks defined in Figure 1. will not necessarily be sufficient to identify the hazards inherent in new technology systems. **Full scale, full scope system safety engineering in accordance with MIL-STD-882 may have to be applied to the design, construction, and test of new technology systems.**

Lesson learned number five is that safety design lessons are derived from preliminary and system hazard analyses, from analysis of historical mishap data and from resolution of design changes driven by identified inherent hazards. These safety design lessons learned should be captured for immediate use on other on-going projects. They are the rationalization for incorporating new safety design criteria into existing design guidance documents such as GENSPECs, MIL-SPECs, MIL-STDs, Standard Drawings, DDS's, and SDS's. **To prevent having to repeatedly learn these lessons, design lessons learned must be documented for interim use and tracked until incorporated into the appropriate design guidance documents.**

Lesson learned number six is that most safety criteria is <u>written in blood</u>. These criteria are considered safety criteria because <u>after-the-fact</u> investigations have identified safety design deficiencies which were the direct cause of the mishap. These criteria are codified, but not annotated in any way, in the *General Specifications for Ships of the United States Navy* (GENSPECS). The safety criteria in GENSPECS have been extracted directly from GENSPECS and distilled into the *General Safety Design Criteria for Ships of the United States Navy* (GENSAFE) along with the rationale for their inclusion. This document is for use by all NAVSEA personnel so that they will be able to readily identify safety design criteria and incorporate those criteria into their ship and system acquisition specifications. **Safety design criteria must be readily identifiable and available to all ship design personnel, not just the "Safety Guys".**

Lesson learned number seven is that upper level management and higher echelon support of the Navy safety program is cyclic in nature. In a period immediately following a severe mishap (heavy personnel and dollar losses) the support of the safety program will increase dramatically. The level of

support will then taper off to a minimal (token) level. Historically, over the past 35 or so years, this cycle has run between eight and ten years. After a number of years with the level of support in a downward trend, hazards creep into designs and operator attention to safety declines. This scenario results in a serious mishap (or series of mishaps) followed by a spike in the level of attention and support. A new declining cycle then begins. **Analysis of the level of support cycle has indicated that a fairly constant level of support of safety, somewhere mid-range between the spike level and the minimal level, would result in elimination of the occurrence of the mishaps which drives the spike, with a net effect of many dollars and lives saved.**

Lesson learned number eight is that even though specific systems engineers and technicians may have received (and will be receiving) training in the application of system safety engineering to systems design, an oversight function still needs to be maintained. In periods of austere budgets, personnel cutbacks, and fast paced designs, the systems engineer will become strapped for resources, both fiscal and personnel. The primary driver for the systems engineer's efforts will be the functional aspects of the system. There is a continuos need for guidance of an oversight nature to bridge this gap. **NAVSEA will maintain a continuos system safety oversight function to ensure that the systems delivered to the Fleet are as safe for the system, the operator / maintainer, and the environment as is feasible within operational requirements and cost constraints.**

<u>These lessons have all been learned as a result of past mishaps which cost millions of dollars and thousands of lives. We must ensure that these lessons are not lost as we move forward into commercialized and performance specifications.</u>

The Advent Of Commercial And Performance Specifications

On October 13th 1994, President Clinton signed the Federal Acquisition Streamlining Act into law. Not long after, Vice President Gore and his committee to reinvent government established the need to use performance specifications in lieu of the conventional ship specifications used to contract and build Navy ships. On the heels of these reforms, the Secretary of Defense directed that the use of Mil-Specs and Standards be either discontinued or used only if there was no commercial specification substitute available.

Change has begun and caught in the middle of this is **System Safety**. These changes present the Navy one of its greatest challenges in the ship design process since the catastrophes of the early sixties.

Ship System Safety Program Goal In The Changeover Process

We cannot fool ourselves into believing that system safety engineering will be automatically performed and that design lessons learned will be applied to the next class of ships. We must be actively involved in the changeover to commercial and performance specifications to ensure that system safety engineering is performed and documented throughout all new designs and that those ships currently under design and construction maintain system safety performance as one of the highest priorities.

The goal of the NAVSEA Ship System Safety Program during this process is to **ensure that the adoption of commercial specifications and preparation of performance specifications results in acquired systems that are at least as inherently safe as systems acquired under conventional military specifications.**

This goal will be achieved by accomplishment of the following objectives:

- maintain an active participation in the changeover process to ensure that the application of system safety engineering as currently practiced becomes a governing requirement in the adoption of commercial specifications and in the preparation of performance specifications.
- ensure that upper level management is kept informed of the positive impact of system safety efforts in design, construction, test, operation, and maintenance.
- develop ship and system specification language to ensure that the application of commercial specifications will result in a product that is at least as inherently safe as the equivalent military specification.
- develop specification language to ensure that systems acquired through performance specifications have been subjected to a system safety program equivalent to current requirements.
- continue the system safety oversight function in support of new ship and ship system development.
- ensure that engineers and technicians receive system safety training.
- apply emerging technology to system safety procedures and methodologies to continue to increase the efficiency of the application of system safety engineering to systems designs.

Conclusion

Accomplishment of the NAVSEA Ship System Safety Program goal and its objectives will ensure delivery of safe, mission capable ships to the Fleet in a commercial / performance specification environment while actively helping to reduce acquisition and life cycle costs, both in dollars and in people.

__Thomas W. Costantino__ was born in Staten Island, New York in 1946. He is currently assigned to NAVSEA 03D7, Human Systems Integration Division. He is the Human Systems Integration Manager for DDG 51, AOE 6, and SC-21. He has been the NAVSEA Senior System Safety Consultant for New Ship Design since 1988. He is a voting member of the NAVSEA Specifications Control Board.

Previously, Mr. Costantino served in NAVSEA 56W44, Hull Outfitting Division, as Life Cycle Manager for structural and non-structural closures, bulkheads, and sheathing systems.

__Kenneth R. Powell__ was born in Dothan, Alabama in 1945. He has an Associate of Science Degree from California Coast University. He retired from the United States Navy in 1987 with the final tour of duty being at the Naval Safety Center, Norfolk, Virginia.

Mr. Powell has been with George G. Sharp, Inc. since retirement from the Navy and is Head, System Safety Branch.

COMMERCIALIZING THE NAVY SHIP ACQUISITION PROCESS

Richard L. Bergner
Ship Design Manager
Surface Ship Design Management Division
SEA 03D3
Naval Sea Systems Command

Stephen Melsom
Ship Design Manager
Surface Ship Design Management Division
SEA 03D3
Naval Sea Systems Command

Michael Safina
Special Assistant for Acquisition Reform
Surface Ship Directorate
SEA 91AR
Naval Sea Systems Command

Robert C. Staiman
Program Manager
John J. McMullen Associates, Inc.

Abstract

The Secretary of Defense, Dr. William Perry, issued memoranda to the Secretaries of the Armed Services in March and June of 1994 directing the use of commercial-like business processes and more specifically, the use of performance specifications in all future acquisitions. The major impact within the Services has been in the efforts to minimize or eliminate references to military specifications and standards from all design packages and to reduce the amount of step-by-step instruction typically given to contractors that go so far as directing internal management procedures.

This paper will summarize the efforts undertaken for the purpose of researching and capitalizing upon "commercial-like" ship acquisition processes for the benefit of all future ship acquisition programs conducted by the Naval Sea Systems Command. It covers the development of a ship owner questionnaire and the face-to-face meetings conducted with various commercial ship owners to discuss their methods of acquiring ships. A notional ship acquisition process has been developed as a result of the meetings and its essential attributes are described.

List of Figures

Appendices

Abbreviations

ASN(RDA)	Assistant Secretary of the Navy (Research, Development and Acquisition)
COMNAVSEA	Commander, Naval Sea Systems Command
COR	Circular of Requirements
DoD	Department of Defense
IPPD	Integrated Product and Process Development
IPT	Integrated Product Team
MARAD	Maritime Administration
MS 0	Milestone 0, Concept Studies Approval
MS I	Milestone 1, Concept Demonstration Approval
MV	Motor Vessel
NASSCO	National Steel and Shipbuilding Company, San Diego, CA
NAVSEA	Naval Sea Systems Command
R&D	Research & Development
RFP	Request for Proposals
SECDEF	Secretary of Defense
TEU	Twenty Foot Equivalent Unit

SNAME	Society of Naval Architects and Marine Engineers
USCG	United States Coast Guard

Background

In March of 1994, the Secretary of Defense, Dr. William Perry, issued a policy memorandum which summarized his beliefs on how the Department of Defense should approach acquisition reform. Included with this memorandum, was his paper "Acquisition Reform - A Mandate for Change" which identified specific goals for a totally re-engineered acquisition system. It stated that in light of a radically changed threat resulting from the end of the Cold War, substantially declining defense budgets and rapidly changing technologies, the existing acquisition system, in many cases, is incapable of responding to meet the Department's needs. The acquisition system must be reengineered to meet these new demands.

Secretary Perry identified several specific objectives, two of which are the primary focus of this paper. These two objectives direct that the Department must:

"Be able to adopt business processes characteristic of world class customers and suppliers; and

"Be free to stop applying Government-unique terms and conditions on its contractors to the maximum extent practicable."[1]

Most professionals within the acquisition community will agree that these two objectives, while seemingly impossible to accomplish, are necessary to achieve the Department's overall goals of cost reduction and advanced technology insertion. Many of the business processes and Government-unique terms and conditions used today are not only founded in law, but embodied in our work ethic. How do we learn about world class business processes? If we stop applying Government-unique terms and conditions, how do we protect the interests of the US Government and maintain full and open competition?

In June of 1994, Secretary Perry issued a second major policy memorandum that redirected the Department in it's approach to how it proceeds in the procurement of new systems. Specifically, he directed that performance specifications be used when purchasing new systems, major modifications, upgrades to current systems and nondevelopmental and commercial items. When it is not practical to use a performance specification, a non-government standard is to be used. Recognizing that this may not always be cost effective, or because military technology may be more advanced, a military specification or standard could be used, but only as a last resort and with a waiver approved by the appropriate decision authority within the Department. It was this memorandum that made it clear that not only was the Secretary serious about his desires for reform, but he was going to take action. This was the "wake-up call" employees in the Department of Defense needed to take action on Dr. Perry's previous memorandum.[2]

Shortly thereafter, several internal initiatives within the NAVSEA community began to take shape. Vice Admiral Sterner, COMNAVSEA, issued a policy memorandum directing commercialization in all NAVSEA programs. Almost all programs in a pre-contract award phase were reevaluated to reduce or remove military specifications and standards references from their design packages. Most notably, the LPD-17 program began a scrub to eliminate and/or tailor over 1400 military and federal specification references in the contract design package. Program office personnel for the Auxiliary Personnel Living Barge developed a performance specification using less than 10 pages (in lieu of the existing 195 page detail design specification.).

However; for shipbuilding programs, nothing specific had been done that addressed the issues of world class processes or commercial-like business practices. What is the commercial ship acquisition process? What is the owner's relationship with the shipbuilder during construction? How do shipyards guarantee the ship will work when delivered? What about logistics? How are spare parts decisions made? How long does it take to build a commercial ship? What does a commercial specification look like? The emerging Auxiliary Dry Cargo Ship [ADC(X)] Program identified a near term need to survey commercial ship owners and ask these very questions. It was the commencement of this program along with the timing of Secretary Perry's

memoranda that led to discussions concerning commercial ship owners.

Ship Owner Process Surveys

In January of 1995 the authors prepared a preliminary list of questions to ask commercial ship owners and solicited inputs from within the NAVSEA Directorates. The initial list contained about 30 questions that addressed concerns of the acquisition community and formed the basis for an evolving questionnaire that was used for industry surveys. The questions were sent to the John J. McMullen Associates, Inc. (JJMA) and the M. Rosenblatt and Son (MRS) New York Offices for review and comment by their commercial ship design personnel. As comments were received, questions were added, deleted or modified as we attempted to "ask appropriate questions" so we could obtain information that would be beneficial to NAVSEA in defining a "commercial ship acquisition process" and to provide input for the development of an acquisition strategy for ADC(X).

At the same time the survey questions were being developed, we assembled a list of representative ship owners to interview. We determined that we needed to interview different types of ship owners to determine how they acquired their ships. The list included tanker operators, both oil companies and independents; container ship owners; and special purpose ship owners. Passenger vessel owners were considered, however time constraints prevented interviewing them.

The initial plan was to go to the New York City metropolitan area and interview a representative sample of companies. Additional ship owner visits would be scheduled at a later date. The New York Office of MRS set up the initial agenda and scheduled three days of meetings with five commercial companies. The companies interviewed were; Great American Lines, Inc. (GALI), Maritime Overseas Corporation (MOC), OMI Corporation, Sea-Land Service, Inc. (SLS), and Universe Tankships (Delaware), Inc. (UT). MOC, OMI and UT are independent tanker and bulker operators; SLS is a container ship operator in liner trades; and GALI owns a special purpose reefer/car carrier which is operated by a sister company. The original NAVSEA questionnaire (See Appendix 1) was given to each of the companies in advance so they could be prepared for the meetings.

As the arrangements for the New York trip were being made, it came to the attention of the Interviewing Team that the Mid-Term Strategic Sealift Research & Development Program was interested in speaking to some of these same companies about incentives that would encourage ship owners to buy and use convertible (Container-Ro/Ro) sealift ships while allowing the Navy to lease them during war time. They prepared a separate economic questionnaire specifically for this trip which was given to the companies at the time of the interview. Selected questions were subsequently included in an updated questionnaire for use in future surveys.

The interviews took place on February 28 through March 2, 1995. The InterviewingTeam consisted of the following personnel:

- Richard Bergner — SEA 03D3, Ship Design Manager for Acquisition Re form
- Stephen Melsom — SEA 03D3, ADC(X) Ship Design Manager
- Wade Webster — SEA 03R1, Mid-Term Stra tegic Sealift R&D Program
- Robert Staiman — JJMA, Acquisition Reform Support
- Philip Kimball — MRS, Acquisition Reform Support
- Naresh Maniar — MRS, Acquisition Reform Support
- Richard Pariseau — Kapos Associates, Mid-Term Strategic Sealift R&D Pro gram

The results of the interviews are summarized below and are included in the Interview Response Matrix, Appendix 2, which covers all interviews:

1. Generally all the companies visited have bought or are presently buying ships using the same general process. They all provide a very limited Owner's Requirement Document to shipyards and request interested shipyards to respond with an outline specification for a modified standard design and a price. The responses are received and the different designs analyzed and clarified to determine which ones best meet the owner's requirements. If there are a number of acceptable proposals, the owners will usually

determine which 3 - 5 proposals they consider to be the best and only continue technical discussions with them. The second round of technical discussions will lead to the selection of a single shipyard with which to continue. At that time a Letter of Intent[i] will be issued to the successful shipyard and intense technical and contractual negotiations will be undertaken to fully define all design requirements, all terms and conditions, and to finalize the price. Upon successful completion of negotiations a contract will be signed. The owners stated that the time frame for this process could be as short as three weeks and as long as six months, but usually ran about three months from inquiry to contract signature.

2. The Owner's Requirement Document contains top level requirements for a proposed acquisition. It will vary in length and detail depending upon the type of ship and the amount of special features the owner desires. An Owner's Requirement Document for a tanker could be as short as two pages and for a special container ship be 60 pages or more. Only if the ship is a one-of-a-kind where shipyards do not have a standard design that can be extrapolated, will an owner develop an in-house design. If the owner develops his own design, it is usually only to a Preliminary Design level of detail and its use will not be mandated upon the shipyard. Only the Owner's Requirement Document will be mandatory.

3. The shipyards will prepare an Outline Specification in response to the owner's solicitation. This is normally a 20-30 page specification which defines a ship in general terms to meet the Owner's Requirement Document. It is typically a description of the shipyard's standard design modified as necessary to be responsive to the requirements of the solicitation. It will not detail any of the systems other than possibly the propulsion plant, electrical plant and major "mission systems". It will usually reference the shipyard's standard practices without detailing them. The purpose of this specification is to show the owners that the shipyard understands their requirements and can design and construct a ship to meet them. It allows the owners to compare the designs proposed by the competing shipyards and provides the technical basis upon which the ship owner bases his decision to continue or not with a particular shipyard. Owners are generally only concerned with general technical descriptions of the ships, delivery dates and prices at this time. This does not mean that the owners do not have an interest in, or understand, many of the "details" of ship design and construction. They leave these things up to the shipyards to allow them to enhance their respective competitive positions.

4. Once an owner has issued a Letter of Intent to a shipyard, the shipyard will begin preparation of the contract specification. The contract specification is a design specification that is roughly 400 pages in length and will describe the ship and all its systems to a level of detail roughly equivalent to a Navy contract design. It will contain a set of contract drawings comprised of, at a minimum, a General Arrangements Drawing, the Midship Section, Machinery Space Arrangements, Accommodation Space Arrangements, an Electrical One-Line Diagram and major mission systems diagrams. The Contract Specification will be provided to the owner for review and then will be negotiated with the shipyard line-by-line and page-by-page until every requirement has been agreed to by both parties. Every page of the contract specification and every drawing are signed by both the shipyard and the owner signifying not only agreement, but understanding of the documents. As part of the detailed technical negotiations, owners usually request "standard practice" documentation for their review and some owners incorporate them into the contract specification. Some owners will hold their detail technical and contractual negotiations in the shipyard so they can talk to the designers or visit a ship under construction to help them understand the methods and quality of the shipyard's construction process. The owners also emphasized that throughout the negotiations, their relationships

[i] A Letter of Intent ia a non-binding agreement between an owner and a shipbuilder that says that if the owner actually buys a ship, that he will buy the ship from that shipbuilder. It is not a committment to buy a ship, but is used to select a shipbuilder with whom to enter into design development and detail negotiations leading toward eventual ship purchase.

with the shipyards are cooperative and not adversarial.

5. The major point emphasized by all owners is that any deviation from the shipyard's standard design will increase the cost of the ship. Shipyards and owners try to minimize design changes so the shipyards can gain production efficiency and the owners can minimize cost growth. Once the technical negotiations are complete and the contract is signed, the shipyard is not obligated to accept any changes from the owner. Therefore, they price changes very high to discourage anything but the most mandatory changes, such as items required by Classification Societies or Coast Guard (USCG) prior to delivery.

6. Commercial shipbuilding contracts are fixed price with liquidated damages for delivery delay and negotiated penalties for non-conformance to performance requirements such as cargo capacity, speed and fuel consumption. There are no incentive or cost type contracts and no escalation clauses. In addition, commercial owners only provide milestone payments to the shipyards according to critical construction events, i.e., contract signature, keel, launch, delivery. The payment schedule is part of the contract negotiations and milestone payments may be equal or weighted towards delivery.

7. All of the owners visited will only buy single shaft, low-speed, diesel powered ships. They insist upon proven reliable engines and provide redundancy in other machinery systems. All owners buy automated ships and design for unmanned engine room operation. All stated they will not buy new technology until it has been proven. They want to be 2-3 years behind the state-of-the-art in technology to verify product reliability and reduce risk.

8. All the owners visited stated they keep their ships in Classification and conform to Flag State and international maritime requirements as well as to USCG requirements for foreign flag ships. Those owners who do have US flagged ships indicated there were cost differentials during construction and an average operating cost increase of up to $2 Mil/year for a US flagged ship. Commercial owners will only have US flagged ships where required by the Jones Act (requires ships engaging in commerce between US ports to be a US flagged ship and US built). They also stated that USCG requirements, Public Health Service requirements and union rules for crew are the major cost differentials. Finally, the Certificate of Financial Responsibility requirements of the Oil Pollution Act of 1990 are also adding a significant insurance cost to tankers calling on US ports.

9. All the commercial owners visited have very small engineering/ design departments and rely heavily upon consultants for design assistance and plan approval All owners insist upon having a small staff of their own inspectors in the shipyard to monitor construction and resolve details. Their in-yard inspectors have no design change authority; that authority is restricted to their corporate headquarters staff only.

10. The responses to the sealift economic issues were generally not as simple as the responses to the acquisition process questionnaire. Those owners who responded brought up the point that a convertible ship with national defense features was not really viable unless the US Government is willing to pay to add those features to the ship and to subsidize the owner for lost cargo capability and/or guarantee cargo preference. Other suggestions were also advanced, but the bottom line was always a method to compensate the owner for cargo loss and a means to protect his business while the ship was in defense use and after its return to the owner.

Subsequent to the New York Trip, the questionnaire was revised to incorporate lessons learned from this first group of interviews, eliminate obviously inappropriate questions, incorporate selected sealift economic questions, and add additional questions relative to life cycle support. As a result of responses from the ship owners, questions relating to cost-type contracting, progress payments, ownership of the ship during construction, and special cost and performance reporting were deleted. The final version of the questionnaire is shown in Appendix 3.

The next interview was held with Mobil Shipping and Transportation Company in Fairfax, VA on April 13, 1995.

The interviewing Team consisted of:

- Richard Bergner — SEA 03D3, Ship Design Manager for Acquisition Re form
- Allen Crout — SEA 03E, Command Specifi cation Improvement Execu tive
- Stephen Melsom — SEA 03D3, ADC(X) Ship De sign Manager
- Robert Staiman — JJMA, Acquisition Reform Support

Mobil Shipping and Transportation Co. (MOSAT) acquires and controls (owned or bareboat chartered) most internationally traded Mobil ships except for ships flagged in France and Australia, which are owned by Mobil affiliates. US flagged ships are controlled by Mobil Supply and Trading. All MO-SAT controlled ships are operated, maintained and crewed by Mobil Shipping Co. Ltd. in London. Therefore, the interview dealt primarily with their acquisition process. Mobil was the first oil company interviewed and provided a very different picture than the independents previously interviewed. While their acquisition process is similar to that of the independents, their philosophies are different. Mobil has a policy of carrying a percentage of their projected world-wide cargo in owned or controlled vessels. Therefore, when acquiring ships today as corporate assests based on long range corporate projections, ship delivery is timed for replacement of older vessels.

Mobil's overall process is the same as the independents, but they take extra time to prequalify shipyards, analyze proposals, and negotiate the technical details. Mobil may spend as long as 9 months from inquiry to contract signature and will only request a proposal from shipyards that they have prequalified for that specific acquisition. The prequalification covers business and financial considerations as well as the yards' recent past experience and quality. A 10-15 page Owner's Requirement Document will then be sent to the prequalified shipyards who will be asked to quote best delivery schedule at the lowest price. Mobil modifies the shipyard's standard design to meet their special design, operational, and maintenance requirements as well as the performance standards for the ship. They require their ships be designed for a 25 year life through the use of conservative structural design, improved tank coatings and specific maintainability requirements. This is in contrast to many of the independentowners who generally require a shorter service life from the ship and buy the shipyard standard design with minimum changes.

The third group of interviews took place on July 19 - 20, 1995 in San Francisco. The companies interviewed were American President Lines, Ltd. (APL), Chevron Shipping Company, and Matson Navigation Company. APL and Matson are in container liner service, with Matson being a US Flagged line primarily in west coast to Hawaii service and APL being primarily trans-pacific. Chevron is in the world-wide tanker service. The NAVSEA team conducting the interviews consisted of the following personnel:

- Judy Cottle — PMS 325, ADC(X) Logistics Manager
- Jim Gerber — SEA 0223, ADC(X) Contract Specialist
- Frank McCarthey — PMS 325, Assistant Program Manager for ADC(X)
- Steve Melsom — SEA 03D3, ADC(X) Ship De sign Manager
- Michael Safina — SEA 91AR, Special Assis tant for Acquisition Reform
- Perry Singh — MIDAS, Inc., Consultant to ATC Program
- Robert Staiman — JJMA, Acquisition Reform Support

APL and Chevron acquire ships world-wide, while Matson recently acquired the MV R. J. Pfeiffer, the first deep draft ocean-going vessel ordered in the US since the early 1980s. Both APL and Chevron generally acquire ships in the same manner as their east coast counterparts, but with differences. The differences will be highlighted rather than going over their entire processes. Matson's experience in acquiring the Pfeiffer has been widely documented and the interview was mainly aimed at clarifying some of the points in the SNAME Paper "Contracting for the Building of a Containership in the U.S. - A Buyer's Story".[3] The APL and Chevron interviews were more directly related to our major topic, definition of a commercial ship acquisition process. The west coast interviews did provide the team with a different perspective than the previous interviews

Chevron acquires ships in a very similar manner to Mobil. They select the shipyards they will invite to submit proposals in advance, but without a formal prequalification process. Their Inquiry Specification (Owner's Requirement) will typically be 50 - 100 pages and contain their special requirements in addition to basic ship performance requirements.

All ship owners conduct extensive plan reviews. One ship owner reviews key plans and system diagrams at the shipyard and the remaining plans in their corporate office. This is done to get their people face-to-face with the shipyard designers in order to get a better understanding of the design. The other owners interviewed conduct plan reviews at their corporate offices.

Contract financing is managed utilizing milestone payments, i.e., contract signature, keel, launch, delivery. Some companies have, at various times, paid for a ship up-front based upon economic factors, cost of money, and/or discounts from the shipbuilders. Whenever they pay up front and in many other situations, ship owners will require a bank refund guarantee or some other suitable performance guarantee to protect their investment. Most ship owners also stated they would contract with a yard they have never done business with if the price is low enough for them to accept the increased performance or delivery risk.

One owner acquires ships in a slightly different manner than the other companies interviewed. Following the same basic approach, Letter(s) of Intent will be sent to one or two successful shipyards and detail contractual and technical negotiations will begin. This particular owner will send a team of naval architects and marine engineers to the shipyard and establish a joint team to develop the contract specifications and Makers' Lists.[ii] The contract specification and Makers' List will become part of the final negotiations and ultimately, be incorporated in the contract. While all ship owners feel that face-to-face contact is important, this ship owner goes one step further and establishes a joint team to insure less misunderstanding and a better design.

[ii] A Makers' List is a complete list of ship equipment with two or three manufacturers acceptable to the shipyard listed for each item. In most cases, the owner will mark one manufacturer as preferred and in some cases owners may have a single source listed. Propulsion and generator engines are usually excluded and listed by make and model in the contract specification.

APL offered a recommendation of how to buy containerships from US shipyards today, based upon their previous US shipyard experience and their present experience with foreign shipyards.

The last ships APL procured from a US shipyard were three PANAMAX[iii] containerships in the 1980-1983 time frame. The contract package was a MARAD format design specification (approx. 3" thick) with 30-35 contract drawings. There were approximately 120 contract changes and all ship deliveries were delayed. APL's experience was that you must give US shipyards much more information up front in order for them to prepare a bid. The US shipyards must be given guidance on general arrangements, structure, machinery arrangements, and model testing because of their lack of commercial experience and the fact that they have no background to draw upon. An owner must also assist them during early negotiations and preliminary design refinement. Finally, the owner must review a lot more of their design products to ensure a good design.

If APL were to acquire ships from US shipyards today, they would use a competitive negotiated approach with a select group of shipyards. They would:

1. Continually watch the world markets, compare worldwide pricing, and establish a competitive budget price for the ship(s). Included would be a budget for all owner's expenses (plan approval, inspection, interest, and changes).

2. Solicit two or three selected shipyards with a performance type inquiry specification. The inquiry specification would have the basic functional requirements such as size, speed, range, TEU count, refrigerated container count, power threshold and would include a General Arrangement drawing. The shipyards would be selected based on past commercial experience, standard practices, credit-worthiness, non-litigiousness, and delivery record, but mostly on APL's belief in the shipbuilder's overall capability to deliver a ship on time and within budget.

[iii] A PANAMAX ship is the largest size ship able to traverse the Panama Canal.

APL would then competitively negotiate with the interested shipyards.

3. APL would request a 6-10 page technical proposal, a non-binding budget price and best delivery date from the shipyards. The proposal should briefly address the top-level build strategy and contain a general ship description. They would allow the shipyards 2-3 weeks from receipt of the inquiry specification to prepare their proposals. Foreign shipyards have much more experience in rapidly and effectively responding to this type of request and the US yards would be encouraged to use a foreign shipyard as a consultant.

4. APL would then review the proposals, and downselect to 2 shipyards.

5. They would then sit down with each yard separately for about one week each, and discuss such things as the shipyard's approach to the design, model testing, the Maker's List, major subcontractors and equipment delivery issues. During this process, APL would also talk to major equipment manufacturers directly and do independent reference checks.
6. After completion of this process, APL would select a single shipbuilder and issue them a non-binding Letter of Intent.

7. The next phase would entail APL sending a group of naval architects, marine engineers and electrical engineers to the shipyard for 4-6 weeks to develop the contract documents. With their shipyard counterparts and working in a joint team, they would write the contract specification and develop a set of key plans. A typical set would contain the General Arrangements; an Electrical One-Line Diagram; Machinery Arrangements including the main engine room and key Auxiliary Space Arrangements such as the purifier spaces; a Firefighting Plan; a Capacity Plan; and a Midship Section. The specification would be typically divided into the Hull, Machinery and Electrical/ Electronics Sections, with the Maker's List appended to it.

8. In parallel with the specification development process, the finance and legal departments of both APL and the selected shipyard would develop the contract language and ancillary details. Delivery date, milestone payments, penalties and liquidated damages would be negotiated. A typical penalties clause would include penalties for speed, container count, deadweight and fuel rate. There would be liquidated damages for delivery delay beyond 30 days. Legal and regulatory body rules and Classification Society would be negotiated. This typically would include all laws, regulations and Classification Society requirements in effect on the date of contract signature. APL would be required to request a change order to implement any change in statutory or regulatory requirements that became mandatory during ship construction

9. The resulting contract would be Firm-Fixed Price with no escalation[iv] factors included. A liquidated damages clause for late delivery would be standard. A warranty clause of one year without a docking would also be standard. There would be language in the contract for liability against flood, fire and force majeure, and a standard clause for default. APL would also require a performance bond. A milestone-based payment plan would be included in the contract. APL would prefer a 5% payment four times during construction and the remaining 80% at delivery. (It is clear that a shipyard would have to be financially healthy to keep the cash flow intact.) The price and delivery would now be defined, all the specifications pages and plans would be co-signed and the final contract signed. Once the contract is signed, the shipyard would have total responsibility for delivering the ship.

10. APL would have an in-yard inspection team to monitor progress and ensure that the ship is built to the approved plans and design. The in-yard inspectors would not have plan approval or design change authority.

[iv] In long term government contracts where the cost of different materials or financing may vary significantly, price adjustment factors, usually based upon Bureau of Labor Statistics indexes, are negotiated into the contract and used to adjust the contract price on a fixed schedule. The price could go up or down based upon these factors.

11. Drawing reviews would take place at APL corporate offices with the standard being 21-28 days for comments and/or approvals. APL would not hold design reviews in the shipyard and only solve problems in-yard, if required.

APL acknowledged that this type of acquisition would be difficult to achieve in the US.

The Matson interview was directed toward their experience in acquiring the MV R.J. Pfeiffer which was delivered in 1992. This was the first new containership acquired by Matson since 1980 and their first diesel powered ship. It is US flagged and operates in the Jones Act trade between the west coast and Hawaii.

Matson recognized in the 1986-87 time frame, while they were solidifying their requirements for a new ship, that the old, "MARAD Way" of acquiring commercial ships was no longer adequate given the lack of commercial shipbuilding in the US and the preoccupation of the US Shipbuilding industry. with US Navy construction. The shipyards themselves were not satisfied with the MARAD process and had also been seeking a better process. Matson, therefore, decided to define an alternate process which was based upon their assessment of successful foreign shipbuilding practices. To overcome objections to the MARAD process, Matson decided to pursue a process which would involve development of the design by the participating shipyards during the proposal preparation phase. Together with consultants they developed a preliminary design which formed the basis for a detailed inquiry specification.

During the specification development period, Matson determined there were seven viable US shipyards who could build the ship and communicated their plans to them. Two shipyards declined to participate due to US Navy commitments and in January of 1988 Matson visited the remaining five shipyards to discuss their planned acquisition in detail. The shipyards were receptive, provided constructive comments and Matson modified their acquisition process and plans to accommodate the shipyards concerns.

Prior to release of the solicitation, one shipyard withdrew due to their unwillingness to invest their own funds in design development, and a fourth shipyard was eliminated based upon Matson's assessment of their financial and managerial instability. The solicitation was finally provided to the remaining three shipyards in August 1988 with a six month proposal development time. During proposal preparation one shipyard was unable to obtain the required performance bond and withdrew. The week before proposal submittal one of the two remaining shipyards decided to withdraw from new construction and concentrate on the repair business. Matson only received one bid; from NASSCO, who took exception to almost every requirement, both technical and contractual. Additionally their bid was significantly over Matson's budget. Matson's experiment with a new ship acquisition process had failed and they began to regroup.

Matson decided to continue with the acquisition project and embarked upon a two pronged effort. First they began to review and revise their requirements. Second they hired NASSCO and Odense Shipyard (Denmark) as consultants and formed a design team to develop a design that would meet budget as well as Matson's revised requirements. The ship was down-sized and many "nice-to-haves" were deleted to bring the ship cost close to Matson's budget. Matson increased their budget by about 8% and contracted for the ship based upon the collaborative design. There were very few contract changes during construction which is a tribute to the collaborative effort to design the ship.

The NASSCO contract was firm-fixed price with no escalation. At contract signature, NASSCO provided a $20M letter of credit to complete the ship at another shipyard in the event of default. There were liquidated damages for delivery delay and no penalties. NASSCO insisted on monthly progress payments which caused Matson problems in assessing monthly progress due to differences of opinion on how to accurately measure progress. A six month guaranty was the most Matson could negotiate while there were warranties of 1 year on main engines and generators and 6 months on paint. Matson negotiated a 5 year anti-fouling warranty with the paint manufacturer which covered them when, after 3 years of service the underbottom began to foul. The MV R.J. Pfeiffer was delivered by NASSCO in August 1992 and has been in service since then.

Prior to contract signature, Matson reviewed all NASSCO yard standards and modified some of them. All applicable standards were listed in the

contract specification. All plans were to be forwarded to Matson. Some of the plans were for review only, but Matson retained the right to approve all plans. They did review all NASSCO Purchase Specifications to insure there were no misinterpretations of specification requirements. Matson had a small in-yard staff of five people during construction who handled day-to-day issues, while all major issues and reviews were handled at Matson corporate offices.

Matson is of the opinion that the US shipbuilding industry today is in no better shape today than it was six years ago when they started their acquisition of the Pfeiffer. They believe the US shipyards still do not have sufficient experience or background in the commercial market and ship owners will have to take this into account in future acquisitions.

Summary of Findings

Discussions with the owners revealed some variations in the specific practices employed to acquire a new ship given the trade, market, and required service life of their vessels. Established relationships with shipbuilders also play a significant role with many of the owners and influences their acquisition procedures. It should be noted that the vast majority of ship owners interviewed dealt only with foreign shipyards. However, several significant similarities were found among the owners interviewed:

- Determination of requirements is completed prior to initiating their ship acquisition processes.
- All use a similar acquisition process which is similar to a NAVSEA two-step COR acquisition using an IPT to develop the contract design.
- All seek a broad response to solicitations for proposals with a rapid down-selection to a single shipbuilder who then prepares the contract design.
- All use performance requirements to initiate the acquisition process, drawings are used as needed for special systems or requirements.
- All use face-to-face discussion and detailed negotiations to reach a mutual understanding and interpretation of specification and contract requirements prior to contract signature.
- The owner/shipbuilder relationship is non-adversarial.
- All use fixed price contracts.
- There are no contract incentives.
- There are no escalation clauses.
- All impose liquidated damages and penalties for delivery delay and non-conformance to performance requirements
- All buy a modified shipyard standard design if it is available. Only when a special purpose vessel is required will the owner produce a preliminary design, but use of this design is not mandated to the shipyards.
- There are virtually no change orders.
- Payments are based on accomplishment of discrete milestones.
- In most cases, the shipbuilder is responsible for obtaining financing.
- The shipbuilders produce the contract design package at their own expense.
- Design change authority is maintained at the owner's corporate headquarters.

Typically, the commercial acquisition process is initiated with the preparation of a requirements document or preliminary design package by the owner (see Figure 1 for a generic commercial ship acquisition timeline). If the requirements document is intended for a standard design tanker or bulk carrier it will likely consist of one to thirty pages or may simply be a verbal inquiry. A vessel for specialized trade or purpose; i.e. refrigerated cargo ships, cable layers, etc., requires a more detailed solicitation package consisting of a requirements document of up to 100 pages in length with drawings of the cargo or mission spaces. An important point here is that ship owners are continually watching their trades for future market opportunities which could determine vessel requirements. The determination and definition of these requirements precedes the start of the commercial acquisition process.

Concurrently, ship owners continually monitor world shipbuilding prices and order books to take advantage of market fluctuations. Shipbuilders are surveyed to see which yards are capable of building the type of vessel desired. Many of the owners indicated they prefer to work with shipyards they have dealt with previously, as they are familiar with the shipbuilder standards and the shipbuilder is familiar with the owner's requirements and preferences. Others contract for best value given a shipyard's demonstrated ability to deliver a similar ship at a

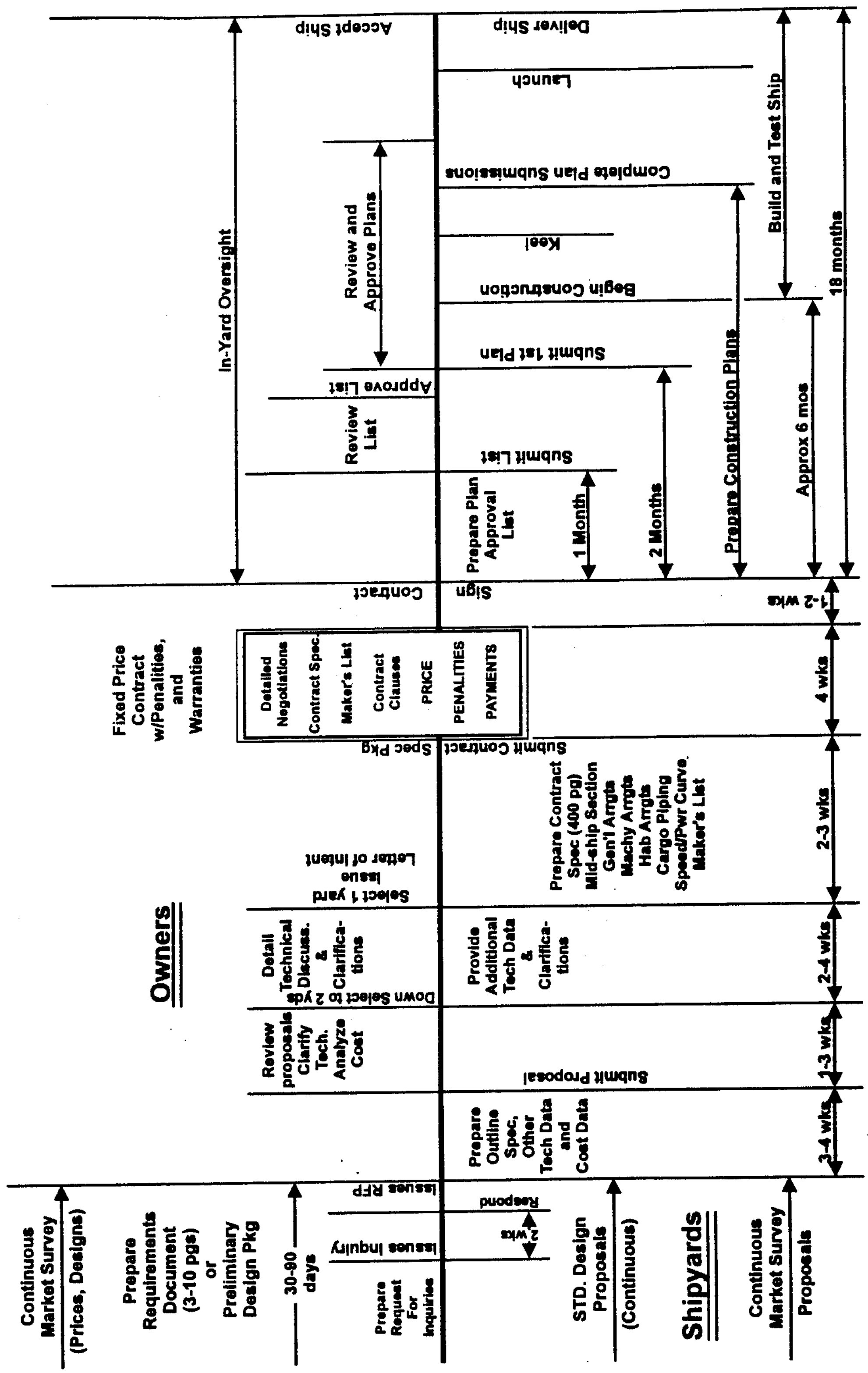
Owners
Continuous Market Survey (Prices, Designs)
Prepare Requirements Document (3-10 pgs) or Preliminary Design Pkg
30-90 days
Prepare Request For Inquiries
Issues Inquiry
Issues RFP
Review proposals Clarify Tech. Analyze Cost
Down Select to 2 Yds
Detail Technical Discuss. & Clarifica-tions
Select 1 Yard Issue Letter of Intent
Spec Pkg
Fixed Price Contract w/Penalities, and Warranties
Detailed Negotiations
Contract Spec
Maker's List
Contract Clauses
PRICE
PENALTIES
PAYMENTS
Contract
Review List
Approve List
Review and Approve Plans
In-Yard Oversight
Accept Ship
Shipyards
STD. Design Proposals (Continuous)
Continuous Market Survey Proposals
2 wks
Respond
Prepare Outline Spec, Other Tech Data and Cost Data
3-4 wks
Submit Proposal
1-3 wks
Provide Additional Tech Data & Clarifica-tions
2-4 wks
Prepare Contract Spec (400 pg) Mid-ship Section Gen'l Arrgts Machy Arrgts Hab Arrgts Cargo Piping Speed/Pwr Curve Maker's List
2-3 wks
Submit Contract
4 wks
Sign
1-2 wks
Prepare Plan Approval List
1 Month
Submit List
2 Months
Submit 1st Plan
Begin Construction
Keel
Complete Plan Submissions
Prepare Construction Plans
Approx 6 mos
Launch
Deliver Ship
Build and Test Ship
18 months

Figure 1

competitive price. If the owner intends to deal with a builder with whom he has no prior experience he may require some level of pre-qualification, depending on the reputation of the builder in question. Among the owners, the pre-qualification process varies in its formality, but usually includes a review of past performance over the last five to ten years. Financial stability, engineering competence, past delivery performance, experience with the type of vessel desired and stability of the labor force are all considered. Most ship owners require a service life of 20 to 35 years except in the specialized trades where a 12 to 15 year service life is the norm. This is particularly true of the refrigerated cargo trade as over-age insurance premiums are required beyond this point per underwriter rules.

In response to an owner's solicitation, the shipbuilder provides a price, a delivery date and an outline specification package which is largely based on a previously used design. This document references shipyard standards and provides little detail; however, it is usually based on a known product and known construction practices, affording a basis for the price. The outline specification is typically 40 to 60 pages for an average vessel. Evaluation and down-selection of the responses is done by the owner's in-house staff (with consultant support as needed) with the shipbuilders being compared against one another on a spreadsheet. Most of the owners down-select to 2 or 3 shipbuilders for further discussion and/or initial negotiation to clarify major issues. Negotiations are conducted for changes to yard standards to meet owner needs, for major equipment preferences and to level the field for price comparison. A letter of intent is then issued to the selected shipbuilder. This is non-binding, yet conveys the intention to enter into detailed negotiations.

The shipbuilder then prepares the contract design specification and drawings at his own expense. The level of detail in these specifications varies (some exceeding 400 pages in length). General arrangements, midship section, machinery arrangements, trim and stability calculations, speed and power calculations and a Makers' List are included as a minimum. Cargo piping systems, cargo space arrangements, mission/cargo machinery arrangements and arrangements of other special purpose spaces are included as required by the owner in accordance with the owner's design guidance. The specification and contract are then negotiated line-by-line and page-by-page attempting to keep the price as originally quoted, but to include those changes deemed necessary by the owner. Face-to-face contact between the owner and the shipbuilder is strongly stressed to minimize misunderstanding and provide a design to meet requirements. (In DoD Acquisition Reform terminology today, this joint team would be considered to be a Specification IPT.) All contracts are fixed priced with no incentives regardless of whether it is a single ship or a multiple ship award with or without priced options.

Performance guarantees and penalties are also negotiated. Given the builder's financial situation and reputation, a refund guarantee or other form of performance bond from a bank that is acceptable to the owner may be required. Penalties are commonly based on lost revenue over the life of the ship and include speed, deadweight and fuel consumption performance. Penalties for deficient speed are usually invoked at 0.3 knot below contract speed with penalties for every 0.1 knot thereafter. The owner is not obliged to accept the ship if delivered speed is greater than 0.9 knot below contract speed.

It should be noted that it normally takes about three weeks for the preparation of the contract design package and four additional weeks for the detailed negotiations to be completed. A relatively small core technical and contract team conducts these intensive negotiations for the owner with design consultants for support. Payment schedules are strictly based on accomplishment of events No accounting or cost performance data is required or needed from the builders.

Upon contract award the shipbuilder prepares the plan approval list for submittal to the owner. Typically, design reviews and approval of major drawings are done at the owner's corporate office, while meetings at the shipyard are held primarily for projectroject status and problem solving. Normally, only minor issues are relegated to the on-site owner team which number four to seven inspectors likely consisting of hull, mechanical, electrical and coatings inspectors plus a chief inspector. Most of the on-site staff are locally hired contractors responsible for over-sight and they typically have no design change authority. Changes, if any, are minimal and are virtually never initiated by the owner. Commercial contracts do not allow the owner the exclusive right to impose changes.

Conclusions

It is intuitively obvious that a private owner has tremendous flexibility when dealing in the international shipbuilding market. World scale competition, reputation and established business relationships between the owner and shipbuilder, and the shipbuilder and vendors significantly affect business decisions and expedite ship acquisition with 13 to 20 weeks as the normal period from inquiry to contract signature. To support this timetable, the requirements determination must be completed prior to initiating an acquisition program. The availability of "standard" or previously built designs provides a firm basis for cost estimation by the shipbuilder to maintain competitive pricing and minimize the risk of unknowns. Very close and continual discussion, negotiation and plan review (in yard and at corporate headquarters) - similar to an IPT - is essential to ensure effective communication and understanding of owner requirements by the shipbuilder.

Recommendations

NAVSEA should adopt a new acquisition process for all future non-nuclear surface ships which incorporates the best practices of commercial ship acquisition and of DoD Acquisition Reform. The new acquisition process should include the following recommendations.

1. **Solicitations for surface ship design and construction contracts should state technical requirements in performance terms and should be issued shortly after MS I.** The survey of commercial ship owners shows they issue their intent to purchase when they have defined their requirements and the market is right for a good price. While the Navy cannot wait for a "good market", the solicitation can be issued as soon as requirements are defined. This would result in issuing a solicitation shortly after MS I. This is the best time in the acquisition process when the Navy is in a position to issue a performance specification which will identify requirements which are realistic yet, still allow for advanced technology insertion. The requirements must be the proper combination of technologies which "push the envelope" in some areas while relying on "proven technologies" in areas where new technology does not contribute to the mission, i.e., where demonstrated operational experience is required.

A performance specification states requirements in terms of the required results with criteria for verifying compliance, but without stating methods for achieving the required results. A performance specification defines the functional requirements for the item, the environment in which it must operate, and interface and interchangeability requirements. As is the case in commercial ship acquisition there will be cases when "how to" requirements (i.e. military specifications) are needed to define an exact design solution. However, they should be used as a "last resort".

The requirements must reflect a balance of being "tough enough" that the shipbuilder will have the incentive to take advantage of Navy knowledge and lessons learned, but not aggressive to the point of being near impossible or only possible at an unacceptable cost. This is a difficult task which requires a significant amount of work on the part of the Navy. The Navy must first decide which components of the ship design will "push" technology, then develop a thorough understanding of the technology state of the art and identify realistic goals. It may be necessary to conduct ship concept studies, including computer analysis and preliminary modeling to set these goals. This effort should occur between MS 0 and MS I and will provide essential information for further definition of the Operational Requirements Document (ORD). Also, during this period the role of the new ship in the Fleet should be analyzed to further define what voids this ship will have to fill. At this stage the "tools" and "talent" required are mostly available within the Navy. It would be wise to have industry involvement, but the Navy would not ready to have the contractor take the lead.

At MS I, the ORD should be approved and issued, signifying it is time to start defining a ship that will meet requirements. If the Navy were to maintain control of the design, develop parts of the ship design "in-house", and provide them as mandatory requirements in the technical package for the solicitation, it might unnecessarily restrict the shipbuilder's flexibility.

Programs may need to vary from the use of total performance specifications in situations where:

- The Navy has invested significant resources in specialized systems or equipment. Combat system components and underway replenishment equipment are two such examples. Funding considerations, as well as component development timelines, may make it essential for the Navy to direct the shipbuilder to use select combat system components. The actual installation and ship integration responsibility for the complete combat system should still reside with the shipbuilder. This philosophy could also be applied to other types of systems and components which are unique to the Navy and require a significant R&D investment of time and money.

- Where equipment or component standardization offers a more affordable alternative when consideration is given to total fleet requirements. For items in this category the Navy could direct their use by the shipbuilder. This is similar to the commercial owner's approach to the Makers' List.

2. **Contract design, detail design and construction should be accomplished by a single shipbuilder.** - This approach is supported by the surveys which revealed that owners select a single shipbuilder very early in the acquisition process and then, work with that shipbuilder to further define their requirements and understand the shipbuilder's processes, and negotiate all requirements or technical changes prior to signing a construction contract. This optimizes the usefulness of the ship design while providing the shipbuilder maximum flexibility to apply his own ship construction processes. NAVSEA can accomplish this same goal by using a contract which, after MS I, works with the design team to define the ship and also provides for a final negotiation of the ship price before construction begins.

There are additional reasons why this should be the preferred concept for Navy ship design contracts. Use of a process which awards several design contracts and then has one or more steps to reduce the number of participants has a negative impact on the quality of the end product (the ship); the time it takes to get a ship under construction; and the cost of the design. This rationale is provided below:

- Product Quality Reduction - The Government does not have the resources to provide equally qualified personnel to multiple ship design teams. Additionally, the shipbuilder is forced to push his design team to define the ship very quickly so that an estimated cost may be developed. He must also dedicate his resources to writing a proposal that is responsive to the RFP instead of working towards the best ship design. The shipbuilder's design team is turned off well before the proposal is submitted and (if they are successful) will not resume work until after the government evaluation is complete and a contract has been awarded.

- Design Cost Increase - The cost of getting to a ship definition is multiplied by the number of teams participating. All of the money spent on the losing designs is wasted unless the Navy spends more money to have the selected shipbuilder incorporate concepts developed by other designteams.

- Increased Time between Design Contract Award and Start of Lead Ship Construction - Each downselect requires preparation of a proposal by the shipbuilders and evaluation by the Navy. This results in a large amount of time being wasted, i.e., not contributing to the design.

3. **The selected shipbuilder should be responsible for total system integration.** Integration and total system performance has traditionally been the Navy's responsibility. By delegating this responsibility the shipbuilder will have the incentive to utilize all available resources to develop the best design.

4. **Contracts should require the utilization of IPTs throughout the ship design and con-**

struction process. A series of IPTs staffed with both Navy and contractor personnel (inclusive of shipbuilders, major subcontractors, and vendors) should be established. These IPTs should establish a continuous concurrent engineering process which utilizes the talents and expertise of all members to their maximum benefit. Applying the tenets of IPPD during the ship design and construction phases will optimize the design, manufacturing and supportability processes.

- Technical Advantages - It is essential that the participating Navy personnel have expert knowledge in their field and be empowered to make decisions. When the contract specification is a detailed "how to" build the ship document, it incorporates the Navy's "lessons learned". When the contract specification is a performance specification the government/ industry IPTs provide the vehicle for transferring this and other valuable "lessons learned" information into the ship design. The result of this effort should be an efficient and cost effective ship design and construction program with minimum design and construction changes, which will provide a superior product to the fleet.

  Commercial ship owners try to accomplish this transfer of knowledge and lessons learned before contracting for the ship. As explained earlier, the ship owner does not sign a contract for ship construction until the contract design package is reviewed and agreed-upon by both parties. In many cases an off-the-shelf design which will meet most of the customer's requirements can be proposed. It is then only a matter of the owner tweaking the design to incorporate features which will provide the operational and service life features that are desired.

- Cost Estimation Advantages - Since US shipbuilders do not have standard designs, cost estimation and price negotiations should not occur until the product is defined by the government/industry team. This approach would provide a high level of confidence cost estimate because it would be based on a high level of product definition.

5. **Source selection criteria should be based on a "best value" approach for ship design and construction.** The best value approach can be defined as: a process used in competitive negotiated contracting to select the most advantageous offer by evaluating and comparing factors in addition to cost or price. It will result in a shift of overall responsibility to the shipbuilder and make it essential that the successful bidder demonstrate more than just a capability to meet the technical requirements at a low cost. The evaluation factors to be used in shipbuilder selection are critical to successful program accomplishment. The traditional functional areas such as Technical, Logistics, Management, Facilities, Cost and Schedule should be evaluated. However the items to be evaluated in each area must consider the data necessary to determine the risk associated with each bidder's proposed approach, and whether each bidder possesses the corporate talent and the facilities necessary to successfully implement their approaches. The most important part of the proposal becomes the shipbuilder's management plan which must demonstrate a total understanding of the complexity of the effort, risk areas, the critical path decisions and an understanding of both the technical and managerial challenges. It must address the significant design milestones, a design and build strategy, as well as, methods of interfacing with Navy participants, major suppliers and vendors and other team members. The management plan should demonstrate how they plan to utilize innovative, world class business, technical and manufacturing processes. Additionally, past performance on programs of similar technical and managerial complexity must be evaluated. Past performance in all of the critical functional areas must be evaluated in detail to determine the risk associated with each functional area. Demonstrated superior past performance in the known risk areas and supporting evidence of the capability to perform will determine the "performance risk" for each bidder. The combination of performance and proposal risks will provide a proposal rating which can then be evaluated against each individual proposal's cost to determine the "best value" to the Navy.

Summary

A ship design process utilizing these tenets complies with Secretary Perry's requirements for acquisition reform while also incorporating Navy "lessons learned" into each ship design.

1. It is a "commercial-like" process. One of the major objectives of Acquisition Reform is for the Government to adopt the practices of world class businesses. The survey findings highlight that the commercial owner's goal is to optimize the usefulness of the ship design while allowing the shipbuilder maximum flexibility to apply his own ship construction processes. By using a contract which incorporates performance specifications, implements the IPPD Process, and provides for a final pricing of the ship once the design is complete and before construction begins, NAVSEA can accomplish this same goal.

2. It is an efficient process. All Post-MS I IPT effort (and funding) is aimed at developing a single optimized design with an integrated construction plan. The knowledge and expertise of all participants in the IPT is used to the fullest extent to optimize the design and construction of the ship. Once the design is sufficiently defined, a competent shipbuilder can accurately price the ship. If the contract is properly structured, this can be done before an option for construction is exercised. Conversely, any work done on design development after MS I that <u>can not</u> be used for construction of the ship is duplicative and non-value added and should be kept to an absolute minimum or eliminated. If multiple contracts are awarded for concurrent design efforts, the information gained from one contract cannot be used to benefit a competing design and will increase the total cost to the Government.

3. It provides for risk management. As a participant in the design process the Government will have access to all aspects of the design, including the shipbuilder's management approach. As a Team Member, the Government can use its expertise to advise the shipbuilder of known risks in his approach and recommend lesser risk alternatives.

4. It incorporates lessons learned. Lessons Learned from prior ship design programs will be incorporated into new designs by open lines of communication between the Government and industry throughout the design. The combined experience of all members of the IPT will be utilized to benefit the ship design The openness of communication and the team spirit fostered by the IPT will break down the barriers to information interchange and allow the best of each concept studied to surface and be incorporated.

Each of these tenets is essential. The real key to success for each program will be striking the proper balance between setting realistic requirements, providing information and support to the contractor and providing the proper incentive the contractor (both through requirements setting and contractual rewards) to deliver a product which meets our needs.

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__Richard. Bergner__ is a Ship Design Manager in the Surface Ship Design Management and Systems Engineering Group at Naval Sea Systems Command (SEA 03D), currently assigned to evaluate the impact of Acquisition Reform and develop the necessary infrastructure for successful implementation of AR initiatives in the ship design process. He has managed several projects including CVN 68 Complex Overhaul Planning, Preliminary Design for a Joint Forces Flagship, and detail design support for construction of the PC 1 Class and all Strategic Sealift ships. Previously he was a Machinery Systems Engineer supporting ship feasibility studies, the CG 47 and DD 963 Classes, and the NFR 90 design. He has been the life cycle manager for the LCAC gas turbine engines. From 1981 to 1984 Mr. Bergner was employed by J.J. Henry Company Inc. as Head of the Machinery Department in the Arlington Office. Mr. Bergner began his career with the U.S. Coast Guard as a design engineer for HVAC and fluid systems.

__Stephen Melsom__ is the Ship Design Manager (SDM) for the Auxiliary Dry Cargo Carrier (ADC(X)) ship acquisition program. His previous assignments include SDM of the Amphibious Assault Ship (LHD) program and Ship Systems Manager for the T-AGOS 23, T-AGS Ocean SWATH, AO 177 Jumboization, AOE 6, and CV Service Life Extension programs. Prior to joining NAVSEA, Mr. Melsom was an engineer for Wesley Wheeler Associates representing European shipbuilders and served as a marine inspector for the U.S. Coast Guard in several U.S. Shipyards. Mr. Melsom holds a B. S. degree from the U.S. Merchant Marine Academy, an M.B.A. from Loyola College and continues to serve in the U.S. Coast Guard Reserve as a marine inspector. He is a member of the American Society of Naval Engineers and the NAVSEA Association of Scientists and Engineers.

__Michael J. Safina__ is the Naval Sea Systems Command Special Assistant for Acquisition Reform, SEA 91R. He is a 1983 graduate of the U.S. Merchant Marine Academy, and began his career at the Charleston Naval Shipyard Design Division. From 1985 to 1987 he was a Project Engineer in the Military Sealift Command assigned to the T-AO 187 Class Fleet Oiler and the Deep Submergence Vehicle Support Ship Programs. In 1987 he joined the Naval Sea Systems Command as a Project Engineer for the T-AGOS 19 Class Ocean Surveillance Program. From 1990 to 1994 he was the Assistant Project Manager on several new ship programs including the T-AGS Ocean SWATH Oceanographic Research project, the Special Forces Mark V Patrol Boat project and the T-AGOS 23 Class Ocean Surveillance Program assigned to the Surface Ship Directorate. In July of 1994, he assumed his present position.

__Robert C. Staiman__ is a Project Manager with John J. McMullen Associates, Inc. He has been with JJMA since retirement from NAVSEA in November 1993 with over 33 years of service. At the time of his retirement he was the Director of the Non-Combatant Ships Design Management Division, SEA 03D4. Previously he was the Director of the Combatant Ships Design Management Division, SEA 03D3. Mr. Staiman was the CG 47 (AEGIS Cruiser) Deputy Ship Design Manager from 1975 to 1979 and the Ship Design Manager from 1979 to 1987. Prior to that he was the Machinery Design Coordinator for the DDG 993 and other ship design programs. Mr. Staiman is a 1960 Graduate of the University of Florida with a degree in Mechanical Engineering and a 1990 Graduate of the Program Managers Course at the Defense Systems Management College.

APPENDIX 1

INDUSTRY SURVEY QUESTIONS - FEBRUARY 1995

SOURCE SELECTION

1. How do you identify potential shipbuilding sources?
   (a) Do you have a long-term relationship with a particular builder or builders?
   (b) Have you ever worked with brokers to select a builder?
   (c) Have you ever conducted a market search?

2. Do you award contracts on a competitive basis or do you negotiate with one or two selected shipyards only?
   (a) If competitive, what level of competition did you seek during ship procurement? (i.e. number of offerors)

3. How do you select a shipbuilder?
   (a) How does/will present US Government Regulations such as Title XI influence your selection?
   (b) To what extent do you consider shipbuilder financial capability before awarding a contract?
   (c) What other significant management/business factors do you consider?
   (d) What technical criteria do you consider?
   (e) Have you ever ordered a ship by telling builders what you would pay?

4. How do you finance newbuildings?
   (a) Do you use corporate funding?
   (b) If not, do you work with banks? Private Investors? Brokers?

CONTRACT

5. How much time do you typically allow between requests for offers and signing of the contract?

6. Do you negotiate final offers with builders regarding:
   (a) Technical details of the vessel?
   (b) Project management?
   (c) Detail cost items?
   (d) Bottom line cost?

7. To what extent do you evaluate cost/price proposals in your shipbuilder selection process?
   (a) What type of cost or pricing information do you require in order to perform an evaluation?

8. Do you provide any type of contract financing to the builder?
   (a) If so, what type?
   (b) What type of payment terms, if any, do your contracts have?

9. Do you have contract incentives for better than expected schedule or penalties for delay?
   (a) Do you give the shipbuilder incentives to propose changes to increase capability?
   (b) For what other items do you provide incentives or penalties?

10. Under what circumstances would you enter into a cost plus contract with a builder?
    (a) Have you ever used a cost plus contract?
11. How long a guaranty period do you require the shipbuilder to provide for the ship after delivery

12. When buying a class of ships, do you order the lead ship with contract options for the follow-ships, or are all the ships ordered at the same time?

13. How are options specified, i.e., window for execution, other relevant terms?

14. Do your contracts contain any provisions for additional, unplanned work or is work negotiated as need arises?
    (a) If the former, do you include rates for additional labor, steel work, etc. in the contract?
    (b) If additional work/changes are negotiated as they occur, how do you avoid delays in implementation?

(c) What type and level of detail do you require when pricing-out additional work/changes?

15. Are there any provisions in the contract to accommodate changes in Federal or International laws and regulations, e.g., EPA regulations?

16. How is title determined throughout construction?

17. Do you require any type of bonding arrangements or corporate guarantees?

18. Do you require a shipbuilder to provide office accommodations for any inspection/ monitoring teams?

TECHNICAL

19. Do you use any type of transportation or cargo loadout models in your requirements determination?
    (a) If yes, are they your models or a consultant's models?

20. Have you ordered ships using your own specifications or by using a shipbuilder provided standard design?
    (a) Have you tried either or both methods?
    (b) If so, what is your opinion as to the merits of either approach?

21. What process will you follow to develop a technical package stating your requirements?
    (a) Do you develop an Owner's Spec in-house or do you use a consultant?
    (b) Typically, what level of technical detail do you use in soliciting offers from builders?
        (1) List of basic particulars?
        (2) Outline specification?
        (3) Contract specification?
        (4) Drawings?
        (5) Testing requirements?
    (c) Do you include" in-house" standard practices or drawings in the package?

22. What technical data do you typically require from the builder (e.g. drawings, studies, models, etc.)?
    (a) With their offer?
    (b) Prior to negotiations?
    (c) With the contract?

23. Do you require builders to submit design products in conformance to particular formats or standards?

24. Do you require the vessel to be built in accordance with any specific regulatory or design standards in addition to SO-LAS, MARPOL, OPA 90, and Class?
    (a) Do you ever require any DoD, Mil, or Fed Specifications or Standards?

25. Are there any special equipments or features you typically ask for?

26. Do you prefer that the builder buy from your list of vendors/equipment, use his own long-term supplier relationships or some combination of the two approaches?
    (a) Have you tried either method?
    (b) If so, what is your opinion as to the merits of either approach?
    (c) Do you ever specify particular vendors in the contract specification (other than in the Maker's List)?
    (d) Do you ever furnish equipment to the shipyard (other than normal outfit items)?

CONTRACT ADMINISTRATION

27. What measures of progress are used to monitor the shipbuilder

28. What is your role after contract award?
    (a) In inspection, technical oversight, progress oversight, review/approval of dwgs.
    (b) Involvement in design process.
    (c) How much authority is granted to your own inspectors in approving changes and change orders?

29. How many people are typically dedicated to a project?
    (a) Full time, part time, skill sets (e.g., engineers, contract administrators, etc.).
    (b) On-site at the building yard?

30. Do you typically see many change orders initiated by the shipyard or claims?
    (a) What has been your experience with the resolution of disputes and claims?
    (b) Is there a specified standard or procedures that are followed to resolve disputes?
    (c) Have you used third-party arbitration?
    (d) If so, was it beneficial?

31. How is casualty and vessel insurance coverage provided for during construction of the vessel prior to delivery?
    (a) Are there requirements set forth in the contract?

32. What is your experience with defaulting a contractor?
    (a) What guidance (statutory regulation, etc.) is followed during the process?
    (b) Are procedures, etc. called out in the contract?

__OPERATIONS & LOGISTICS__

33. How do you support/maintain your ships after delivery?

34. Do you have any plans/programs in place to standardize components or equipment across your fleet?

35. What are your maintenance philosophies (at-sea, pier-side, and during yard periods)?
    (a) Do you maintain any parts in inventory?
    (b) How do you determine what spare parts to buy and put aboard ship?
    (c) How do you identify the parts, get them ordered, and to the ship?
    (d) How do you address spares in the building specification, e.g. Class requirements only, maker's recommendations, detailed list of specific types of components?

36. How do you develop operating & maintenance instructions (e.g., technical manuals) for the ship's crew?

37. Do you typically require any special operating manuals from the builder or are individual vendor manuals sufficient?

38. Is training provided for as a part of the building contract?

39. How long are operating crews kept at sea?

40. How do you address "quality of life" for your crews?

__REGULATORY BODIES__

41. Are any of your ships US Flagged?
    (a) If not, what flag do they fly?

42. How much do you rely on regulatory body inspections in lieu of your own inspection approvals?
    (a) During construction?
    (b) During Acceptance Trials?

43. If you rely solely on regulatory body inspections, have you had any problems with this approach?

44. Are your ships delivered and maintained in Classification?
    (a) Which Classification Society do you use or have you used?
    (b) Are all ships in your fleet Classed with the same Society or do you use more than one Classification Society?

COST

45. Do you develop cost estimates prior to negotiations with prospective builders?
    (a) What cost-estimating relationships do you use?

46. Do you address the "life-cycle" cost of the ship in the contract or in your analysis of the offers?

47. Under what circumstances would you require ship construction cost reporting during performance of the contract?
    (a) Would you require such information in a specified format or would you rely on the builder's cost accumulation system?

APPENDIX 2

INDUSTRY SURVEY QUESTIONNAIRE MATRIX

	Ship Owner # 1	Ship Owner # 2	Ship Owner # 3	Ship Owner # 4	Ship Owner # 5
SOURCE SELECTION					
1. How do you identify potential shipbuilding sources?	Long term relations	Historical Basis	Major yards only, past experience	Survey the Industry	Survey the Industry
(a) Do you conduct a market search?	Yes	No	Yes	Yes	Yes
(b) Do you limit your choice of builders to a particular geographic area?	Japan & Korea	Japan	No	Far East Asia	No
(c) Have you ever worked with brokers to select a builder?	No	No	No	Yes	With Partners
2 How do you select a shipbuilder?	Competitive	Competitive	Competitive	Competitive	Competitive
(a) If competitive, what level of competition did you seek during ship procurement? (i.e. number of offerors)	2	2-3 yards	4-5	2 - 3	All pre-qualifed yards
(b) Do you have a long-term relationship with a particular builder or builders?	Hyundai & Hitachi	In past w/IHI	No	No	No
(c) To what extent do you consider shipbuilder financial capability before awarding a contract?	Always	Always	Credit worthiness	Always	Always
(d) What other significant technical/management/business factors do you consider?	Yard Stability and Quality	Yard Stability and Quality	Delivery, capability, non-litigiousness,experience	Yard Stability and Quality	Past Performance
(e) Have you ever ordered a ship by telling builders what you would pay?	No	No	No	No	No
(f) How does/will present US Government Regulations such as Title XI influence your selection?	Not Discussed	Not Discussed	None	No Impact	No Impact
3. How do you finance newbuildings?	Most Economical Way	Not Discussed	Not Discussed	Not Stated	Most Economical Way
(a) Do you use corporate funding?	Sometimes			Not Stated	Sometimes
(b) Do you work with banks? Partners? Brokers?	Not Stated			Partners	Banks & Partners
(c) Do you use shipbuilder financing packages?	Yes			Not Stated	Yes
CONTRACT					
4. How much time do you typically allow between requests for offers and signing of the contract?	3 wks to 3 mos	Not Discussed	4 months	3 Mos	9 Mos
5. Do you negotiate offers with builders regarding:					
(a) Technical details of the vessel?	Yes	Yes	Yes	Yes	Yes
(b) Project management/in-yard inspection?	Yes	Not Stated	Yes	Yes	Yes
(c) Detail cost items?	Yes	Yes	Not Stated	Yes	Yes
(d) Bottom line cost only?	Yes	Yes	Yes	Yes	Yes
6. What type of payment terms , if any, do your contracts have?	Milestone Payments	Not Discussed	Milestone Payments	Milestone Payments	Milestone Payments and 100% up front
7 Do you require any type of bank or corporate guarantees?	Not Discussed	Not Discussed	Performance Bond	Bank Refund Guarantee	Performance Guarantee if 100% paid up front
8 Do your contracts contain liquidated damages and/or penalties?	Not Discussed	Yes	Yes	Yes	Yes
(a) For what items do you specify liquidated damages?		Delivery	Delivery	Delivery	Delivery
(b) For what items do you specify penalties?		Speed, Fuel Rate, Deadweight	Speed, TEU, Deadweight, Fuel Rate	Deadweight, Speed	Speed, Fuel Rate, Discharge Rate, Dynamic Positioning, Deadweight
9 How long a guaranty period do you require from the shipbuilder?	1 Year	Not Discussed	1 yr	1 Year	1 Yr
(a) Do you ever specify any special guarantees for engines or coatings, etc.?	Not Discussed		Not Stated	3-5 Yrs new main engine and coatings	3-5 Yr Coatings, 2 yrs Shuttle Tanker
(b) Do you require a guaranty docking at the end of the guarantee period?	Not Discussed		No	Not Stated	Yes
(1) In the building yard?					
(2) Anywhere?					Yes
10 When buying a class of ships, do you order the lead ship with contract options for the follow-ships or are all the ships ordered at the same time?	All at same time	Options	All at once	1or 2 plus options	Both
11 Are there any provisions in the contract to accomodate changes in Federal or International laws and regulations e.g., EPA regulations?	No changes expected	Not Discussed	No	No changes expected	No
12. Do you require a shipbuilder to provide office accommodations for your in-yard personnel?	Yes	Not Discussed	Yes	Yes	Yes
TECHNICAL					
13. Do you use any type of transportation or cargo loadout models in your requirements determination?	No	Not Discussed	Corporate Strategic Planning	Not Discussed	Not Discussed
(a) If yes, are they your models or a consultant's models?			In-house		
(b) If no, how do you determine ship requirements?	Buy on speculation consistent with industry	"Bigger was Better"		Historical trends in industry and company	

APPENDIX 2

INDUSTRY SURVEY QUESTIONNAIRE MATRIX

	Ship Owner # 1	Ship Owner # 2	Ship Owner # 3	Ship Owner # 4	Ship Owner # 5
14. What is your optimal size ship?	VLCC & Cape Size Bulker	VLCC	4800 TEU	Not Discussed	Varies
(a) What are the most critical factors/assumptions underlying your answer?	Not Stated	"Bigger was Better"	Not Stated		Ship Service
15. Do you order ships using your own specifications or by using a shipbuilder standard design?	Shipbuilder Std Design	Both	Modified Std Design	Shipbuilder Std Design	Both
(a) Have you tried either or both methods?	N/A	Yes	Yes	N/A	Yes
(b) If so, what is your opinion as to the merits of either approach?	N/A	Today would use Standard Designs	US yds need a design, std design elsewhere	N/A	Depends on ship type
16. What process do you follow to develop a technical package stating your requirements?					
(a) Do you develop an Owner's Requirement/Outline Spec, a design package or a Contract Spec?	Buy standard designs to Owner's Reqt	Design in past	Outline Spec.	Owner's Reqt or Spec.	Owner's Req't or Functional Spec
(b) How long does it normally take?	Not Stated	Not Stated	4 Weeks	Not Stated	Not Stated
(c) In-house or do you use a consultant?	In-House	In-house & Builder	In-house	In-House	In-House
(d) Are there any special equipments or features you typically ask for?	Upgraded scantlings, midship & coatings, min. HTS, Low Spd Diesels	Upgraded scantlings, materials & coatings	APL approved vendors & certain designated vendors	Low Speed Diesel Engines, ACCU, Integrated control systems	Maintainability Features, ACCU, Low Speed Diesels, Structure
17. What technical data do you typically require from the builder, e.g. drawings, studies, model tests, etc.?					
(a) With their initial offer?	Outline Spec	Outline Spec	Design proposal	Outline Spec	Outline Spec
(b) Prior to negotiations?	ClarifyTechnical Details	ClarifyTechnical Details	Design proposal clarifications	Technical Details, Maker's List, Main Engine, Class Society	Technical Details, Maker's List,Dwgs, Special Structure
(c) With the contract specification?	Contract Spec, Maker's List, Drawings, Class Society	Contract Spec, Maker's List, Yard Standards	Contract Spec, Maker's list	Contract Spec, Maker's List, Dwgs, Yard Standards , Penalties	Contract Spec, Maker's List, Drawings, Penalties
18. Do you require builders to submit plans or other design products in any particular formats or standards?	Not Discussed	Not Discussed	No	Not Discussed	Not Discussed
19. Do you do plan approvals in-yard or in your own offices?	Office	Office	In Office	Office	Both
(a) Do you use consultants for plan approval?	Yes	Yes	Yes	Yes	Yes
20. Do you require the vessel to be built in accordance with any specific regulatory or design standards in addition to SOLAS , MARPOL, OPA 90 and Class?	Upgraded Class Stds	Upgraded Class Stds	No	No	ABS DLA Method
21. Do you ever specify particular vendors in your requirements or do you accept the builder's Maker's List?	Negotiate List	Negotiate List	Approved Vendors & Negotiate List	Main Engine & Negotiate	Negotiate List
CONTRACT ADMINISTRATION					
22. What is your role after contract award?		Not Discussed			
(a) Inspection, techncial oversight, progress oversight, review/approval of dwgs.	Yes		Yes	Yes	Yes
(b) How much authority is granted to your own in-yard personnel in approving changes and change orders?	No major changes		Not Stated	No Design Changes	Plan Revision Approval
23. How many people are typically dedicated to a project?		Not Discussed	Not Discussed		
(a) Full time, part time, skill sets (e.g., engineers, contract administrators, etc.).	2-3 in-hse + Consultants			1-2 in-hse + Consultants	Not Stated
(b) On-site at the building yard?	3-4 or more			3-4/ship, up to 6 total	5 - 7
OPERATIONS & LOGISTICS					
24 How many ships do you operate and maintain?	30 + Tankers& Bulkers	8 Tankers & 4 Bulkers	Not Stated	Not Stated	Not Stated
25. What are your maintenance philosophies (at-sea, pier-side, and during yard periods)?	All	All	All	All	All
26. How do you support/maintain your ships after delivery?	Crew at-Sea Maint. & Riding Crews	Crew at-Sea Maint & Riding Crew for Boilers	Crew at Sea Maint., Riding Crews & Dockside	Crew at-Sea Maint. & Riding Crews	Crew at-Sea Maint, Riding Crews, Dockside
(a) Do you employ maintenance personnel to augment the ships' crews or are crews responsible for maintenance or repair?	Riding Crews	Riding Crews	Riding Crews	Riding Crews	Riding Crews
(b) Do you have repair/support contracts with shipbuilders or installed equipment manufacturers?	Not Stated	Not Stated	OEMs	Not Stated	Not stated
27. How do you address spares in the building specification, e.g., class requirements, maker's recommendations, detailed list of specific components?	Not Discussed	Not Discussed	Detailed List	Owner's List	Not Discussed
28. Do you buy any spare major components with your ship, such as engines, pumps, valves?	Not Discussed	Bought lifetime spares for steam ships	Tailshaft, Prop & timing gears for class	Not stated	Not Discussed

APPENDIX 2

INDUSTRY SURVEY QUESTIONNAIRE MATRIX

	Ship Owner # 1	Ship Owner # 2	Ship Owner # 3	Ship Owner # 4	Ship Owner # 5
29. What is your sparing philosophy?		Bought 20 yrs spares			Not Discussed
(a) Do you maintain any parts in inventory?	Yes	Yes	Yes	Yes	
(b) How do you determine what spare parts to buy and put aboard ship?	Not Discussed	Spares in warehouse.	Vendors & crew	Repair Dept Recomm.	
(c) How do you identify the parts, get them ordered, and to the ship?	Not Discussed	Port Engineers	Vendor Contracts	Not Discussed	
30. How do you determine whether to repair or replace equipment on your ships?	Not Discussed	Not Discussed	Not Discussed	Not Discussed	Not Discussed
(a) Do you have a price ceiling for equipment repair vis a vis replacement?					
31. Do you have any plans/programs in place to standardize components or equipment across your fleet?	Not Discussed	Yes	Yes	Not Discussed	Stdze Mfgrs.
32. How do you schedule ship drydocking overhauls?	Class Reqts	Class Reqts	Not Discussed	Not Discussed	Not Discussed
(a) Do you follow Classification Society recommendations?	Yes	Yes			
(b) Do you have regularly scheduled repair periods between dockings and overhauls?	Not Stated	Not Stated			
33. How do you support ship drydocking overhauls?	Not Discussed		Not Discussed	Not Discussed	Not Discussed
(a) Go back to the shipbuilder for overhauls?		No			
(b) Do the work yourself?		Some			
(c) Contract out to the best bidder?		Yes			
34. Do you develop operating & maintenance instructions for the ship or do you accept builder's and vendor's manuals?	Not Discussed	Not Discussed	Not Discussed	Builder's Manuals	Not Discussed
(a) Do you typically require any special operating manuals?	Not Discussed			No	Not Discussed
(b) Does each ship carry a library of manuals and drawings to sea?				Not Stated	Not Discussed
35. Is crew training provided for as a part of the building contract?	Not Discussed	Not Discussed	Limited Familiarization	Not Discussed	Not Discussed
(a) How do you manage follow-on training when personnel changes occur?			Not Stated		
36. What kind of damage control equipment do you have on your ships?	Not Discussed	Not Discussed	Not Discussed	Not Discussed	Not Discussed
(a) Do you provide damage control/firefighting training for your crews?					
37. How are your ships crewed, i.e., nationality?			Not Discussed		
(a) Officers?	Korean, Italian, Filipino	German		Filipino, Indian	English, Indian, French, Australian
(b) Unlicensed?	Korean, Filipino	Filipino		Filipino, Indian	English, Indian, Filipino, French, Australian
38. Do you have women officers or crew on your ships?	None on Foreign Flag, Some on U.S.	No	Not discussed	None on Foreign Flag, Some on U.S.	Did Not Know
39. How long are operating crews kept at sea?	8 mos on/4 off	6 mos +	Not Discussed	Not Discussed	Not Discussed
40. How do you address "quality of life" for your crews?	Wives & kids>5 allowed	Officer's Wives Allowed	Not Discussed	Not Discussed	Not Discussed
REGULATORY BODIES					
41. Are your ships U.S. Flagged?	Some US	No	No	Some US	One
(a) If not, what flag do they fly?	Not Stated	Liberia	Not Stated	Most Liberia	Liberia, Marshall Is, Bermuda, France, Australia
42. Do you rely on reg body and Classification Society inspections in lieu of your own inspection and approvals?	Owner's Reps In-Yard	Not Discussed	Owner's Reps In-Yard	Owner's Reps In-Yard	Owner's Reps In-Yard
(a) If you rely solely on regulatory body inspections, have you had any problems with this approach?					
43. Are your ships delivered and maintained in Classification?	Yes	Yes	Yes	Yes	Yes
(a) Which Classification Society do you use or have you used?	ABS, Lloyds, DNV, NKK	ABS	ABS	ABS and Others	ABS, LRS DNV, NK, BV
(b) Are all your ships classed with the same Society or do you use more than one Classification Society?	ABS & Lloyds	ABS	Not discussed	ABS and Others	ABS, LRS DNV, NK, BV
COST					
44. Do you develop cost estimates prior to negotiations with prospective builders?	Yes	Not Discussed	Not Discussed	Not Discussed	Not Discussed
(a) What cost-estimating relationships do you use?	Not Discussed	Not Discussed			
45. Do you consider "life-cycle" cost of the ship in your analysis of the offers?	Yes	Yes	Not Discussed	Yes	Yes
46. When you buy a ship, how quickly do you expect to realize a return on investment?	25 Yr Useful Life	Keep Ships up to 35 Years	Not Discussed	20 Yr ROI	Not Discussed
47. What, if any, cost savings do you realize by using foreign flag?	Approx $2 Mil/Yr	Not Discussed	Not Discussed	Approx $2 Mil/Yr	Not Discussed
48. Wh t are the largest cost contributors for operating U.S. flagged? (e.g., crew size, wages, USCG regulations, union rules, Environmental Issues, etc.?)	Crew costs, Insurance	COFR and Insurance	Not Discussed	Wages, USCG Regulations	Not Discussed

APPENDIX 2

INDUSTRY SURVEY QUESTIONNAIRE MATRIX

	Ship Owner # 6	Ship Owner # 7	Ship Owner # 8	Ship Owner # 9
SOURCE SELECTION				
1. How do you identify potential shipbuilding sources?	Survey the Industry	Prelim. Inquiries	US Yards only	Survey the Market
(a) Do you conduct a market search?	Yes	Yes	Yes	Yes
(b) Do you limit your choice of builders to a particular geographic area?	Far East Asia	No	No	No
(c) Have you ever worked with brokers to select a builder?	Yes	Yes	Yes	Not Discussed
2 How do you select a shipbuilder?	Competitive	Competitive	Competitive	Competitive
(a) If competitive, what level of competition did you seek during ship procurement? (i.e. number of offerors)	2	Max @ early stages	2	2 - 5
(b) Do you have a long-term relationship with a particular builder or builders?	No	No	No	No
(c) To what extent do you consider shipbuilder financial capability before awarding a contract?	Always	Always	Considered	Considered
(d) What other significant technical/management/business factors do you consider?	Stability & Quality	Yard Stability and Quality	Delivery, Quality	Yard Stability, Past Performance, Delivery
(e) Have you ever ordered a ship by telling builders what you would pay?	No	No	No	Not Discussed
(f) How does/will present US Government Regulations such as Title XI influence your selection?	No Impact	No Impact	Not Discussed	Not Discussed
3. How do you finance newbuildings?	Not Stated			Most Economical Way
(a) Do you use corporate funding?	Not Stated	Not Stated	Not Discussed	Sometimes
(b) Do you work with banks? Partners? Brokers?	Partners	No		Not Stated
(c) Do you use shipbuilder financing packages?	Not Stated	Banks, Brokers		Not Stated
		Not Stated		
CONTRACT				
4. How much time do you typically allow between requests for offers and signing of the contract?	3 Mos	3 Mos	Not Discussed	8 - 9 Months
5. Do you negotiate offers with builders regarding:	Yes	Yes	Yes	
(a) Technical details of the vessel?	Yes	Yes	Yes	Yes
(b) Project management/in-yard inspection?	Yes	Yes	Yes	Yes
(c) Detail cost items?	Yes	Yes	Yes	Yes
(d) Bottom line cost only?				Yes
6. What type of payment terms , if any, do your contracts have?	Milestone Payments	Milestone Payments	Monthly Progress Payments	Milestone Payments and 100% up front
7 Do you require any type of bank or corporate guarantees?	Refund guarantee	Bank Refund Guarantee	$20 Mil Ltr of Credit for default & fix ship	Refund Guarantees
8 Do your contracts contain liquidated damages and/or penalties?	Yes	Yes	Yes	Yes
(a) For what items do you specify liquidated damages?	Delivery	Delivery	Delivery	Delivery
(b) For what items do you specify penalties?	TEUs, Speed, Fuel Rate, Deadweight	, Power, Cargo Area, Dead	Speed	Speed, Fuel Rate, Deadweight
9 How long a guaranty period do you require from the shipbuilder?	1 Year	1 Year	1 yr request, 6 mos negotiated; Engines & Gen 1 yr, paint 6mos	1 yr
(a) Do you ever specify any special guarantees for engines or coatings, etc.?	Not Stated	Not Stated	en Sets 1 yr, Paint 6 mos,	Coatings 3 - 5 yrs, New items 2 yrs
(b) Do you require a guaranty docking at the end of the guarantee period?	Yes	Yes	Not Stated	No
(1) In the building yard?	Not Stated			
(2) Anywhere?	Not Stated	Yes		
10 When buying a class of ships, do you order the lead ship with contract options for the follow-ships or are all the ships ordered at the same time?	Have multiple ships under contract	Not Discussed	Not Discussed	All at one time
11 Are there any provisions in the contract to accomodate changes in Federal or international laws and regulations e.g., EPA regulations?	No, Owner's Resp.	No, Owner Will Implement if Wanted	No	No
12. Do you require a shipbuilder to provide office accommodations for your in-yard personnel?	Yes	Yes	Yes	Yes
TECHNICAL				
13. Do you use any type of transportation or cargo loadout models in your requirements determination?	Business Planning Group	No	Yes	Corporate strat planning & Tonnage Curves
(a) If yes, are they your models or a consultant's models?	Both		In-house	In-house
(b) If no, how do you determine ship requirements?		Intuitive Guess		

APPENDIX 2

INDUSTRY SURVEY QUESTIONNAIRE MATRIX

	Ship Owner # 6	Ship Owner # 7	Ship Owner # 8	Ship Owner # 9
14. What is your optimal size ship?	4000+ TEUs	Not Stated	Determined by Service	Not Stated
(a) What are the most critical factors/assumptions underlying your answer?	Trade Routes & Market	Market Evaluations		
15. Do you order ships using your own specifications or by using a shipbuilder standard design?	Both	Both	Both	Std Design
(a) Have you tried either or both methods?	Yes	Yes	Yes	
(b) If so, what is your opinion as to the merits of either approach?	Own designs in past, standard designs today	Complexity of ship determines	US Yards need a design	
16. What process do you follow to develop a technical package stating your requirements?				
(a) Do you develop an Owner's Requirement/Outline Spec, a design package or a Contract Spec?	Owner's Reqt	Owner Reqts and Prelim. Design	Tried all	Outline Spec
(b) How long does it normally take?	Not stated	3 Mos for Design	Not Stated	Not Stated
(c) In-house or do you use a consultant?	In-House	Both	In-hse w/consults.	In-house
(d) Are there any special equipments or features you typically ask for?	Special Features, Low Speed Diesel Engines, Med Speed DGs, ACCU	Reefer Systems, Scantlings, Coatings, Class Society	Container Lashings, model testing	Coatings, HTS usage, Model Testing, Side shell connections
17. What technical data do you typically require from the builder, e.g. drawings, studies, model tests, etc.?			Everything	
(a) With their initial offer?	Outline Spec	Outline Spec		Mod to Std Spec, GA, Elec 1Line, Major Sys Dia, Spd/Pwr, Fuel Rate
(b) Prior to negotiations?	Technical Details, Maker's List, Fatigue Analysis, Class Society	ClarifyTechnical Details		Clarifications & Design Spec
(c) With the contract specification?	Contract Spec, Maker's List, Drawings, Penalties	Maker's List, Yard Standar	Contract Design	Design Spec, GA, Midship, Machy Arrgt, Major Sys Dia, Block/ Break Plan, Build Strategy, Maker's List
18. Do you require builders to submit plans or other design products in any particular formats or standards?	Not Discussed	Reg Body Reqts	No	No
19. Do you do plan approvals in-yard or in your own offices?	Office	Office	In Office	Key Plans in-yd, others in Office
(a) Do you use consultants for plan approval?	Yes	Yes	Yes	Not Stated
20. Do you require the vessel to be built in accordance with any specific regulatory or design standards in addition to SOLAS, MARPOL, OPA 90 and Class?	No	Flag State Rules	No	ABS DLA & SAFEHULL
21. Do you ever specify particular vendors in your requirements or do you accept the builder's Maker's List?	Negotiate List	Main Engine & Negotiate List	Negotiated List	Negotiated List
CONTRACT ADMINISTRATION				
22. What is your role after contract award?				
(a) Inspection, techncial oversight, progress oversight, review/approval of dwgs.	Yes	Yes	Yes	Yes
(b) How much authority is granted to your own in-yard personnel in approving changes and change orders?	No Design Changes	Not Discussed	No Design Changes	No design Changes
23. How many people are typically dedicated to a project?				
(a) Full time, part time, skill sets (e.g., engineers, contract administrators, etc.).	1-2 in-hse + Consultants	1 In-Hse + Consultants	Not Stated	Not Stated
(b) On-site at the building yard?	3-4/ship	4-Mar	5	5
OPERATIONS & LOGISTICS				
24 How many ships do you operate and maintain?	Not Stated	1 Reefer/Car Carrier	Not Stated	Not Stated
25. What are your maintenance philosophies (at-sea, pier-side, and during yard periods)?	All	All	All	All
26. How do you support/maintain your ships after delivery?	Crew at-Sea Maintenance	Crew at-Sea Maintenance & Dockside	Crew and Riding Crews at Sea, ContractorsDockside	Crew-at Sea Maint., Riding Crews, OEMs
(a) Do you employ maintenance personnel to augment the ships' crews or are crews responsible for maintenance or repair?	Not Stated	Not Stated	Riding Crews	Riding Crews
(b) Do you have repair/support contracts with shipbuilders or installed equipment manufacturers?	Not Stated	Not Stated	Yes	Electronics, Aux engines
27. How do you address spares in the building specification, e.g., class requirements, maker's recommendations, detailed list of specific components?	Not Discussed	Not Discussed	Negotiated List	Not Stated
28. Do you buy any spare major components with your ship, such as engines, pumps, valves?	Not Stated	Not Discussed	Tailshaft and Prop	Prop, Tailshaft, Turbo for Class. Cyl liner, head & piston for engines

APPENDIX 2

INDUSTRY SURVEY QUESTIONNAIRE MATRIX

	Ship Owner # 6	Ship Owner # 7	Ship Owner # 8	Ship Owner # 9
29. What is your sparing philosophy?	Private Contractor for Engine Rm Spares			Reduce Spares/ Contract forMaint. 24 hr OEM Parts Delivery
(a) Do you maintain any parts in inventory?	Private contractor	Yes	Yes	Yes
(b) How do you determine what spare parts to buy and put aboard ship?	Private contractor	Not Discussed	Maint Contracts	Crew & OEMs
(c) How do you identify the parts, get them ordered, and to the ship?	Private contractor	Not Discussed	Maint Contracts	OEMs & Contracts
30. How do you determine whether to repair or replace equipment on your ships?	Not Discussed	Not Discussed	Not Discussed	Analyze life cycle costs
(a) Do you have a price ceiling for equipment repair vis a vis replacement?				No
31. Do you have any plans/programs in place to standardize components or equipment across your fleet?	Not Discussed	Only for Multi-Ship Buys	Yes	Lifeboats & Electronics
32. How do you schedule ship drydocking overhauls?	Not Discussed	Not Discussed	Not Discussed	5 yr cycle/Coatings
(a) Do you follow Classification Society recommendations?				Yes
(b) Do you have regularly scheduled repair periods between dockings and overhauls?				Not Stated
33. How do you support ship drydocking overhauls?	Not Discussed	Not Discussed	Not Discussed	Partnership w/2 yds
(a) Go back to the shipbuilder for overhauls?				
(b) Do the work yourself?				
(c) Contract out to the best bidder?				Singapore & Portugal
34. Do you develop operating & maintenance instructions for the ship or do you accept builder's and vendor's manuals?	OEM Manuals, Develop own Operations Manuals	Builder Provides	OEM Manuals, Develop own Operations Manuals	OEM Manuals, Develop own Operations Manuals
(a) Do you typically require any special operating manuals?	No	No	No	Develop own
(b) Does each ship carry a library of manuals and drawings to sea?	Not Stated		Not Discussed	Not Stated
35. Is crew training provided for as a part of the building contract?	Not Discussed	CHENG & 1st In-Yd	Not Discussed	Limited Familiarization
(a) How do you manage follow-on training when personnel changes occur?				OEM Training
36. What kind of damage control equipment do you have on your ships?	Not Discussed	Not Discussed	Not Discussed	Not Discussed
(a) Do you provide damage control/firefighting training for your crews?	Not Discussed			
37. How are your ships crewed, i.e., nationality?	Not Discussed		US Crews	
(a) Officers?		Polish	US	UK,Swedish, Norwegian, German, Italian, India Jrs
(b) Unlicensed?		Filipino	US	Indian, Filipino
38. Do you have women officers or crew on your ships?	Not Discussed	Not Stated	Not Discussed	US Officers, Foreign unlicensed
39. How long are operating crews kept at sea?	Not Discussed	Offr-6 mos; Crew 12 mos	Not Discussed	Offr 4 mos; crew 6/9 mos
40. How do you address "quality of life" for your crews?	Not Discussed	Not Discussed	Not Discussed	Upgraded Accom, Pools, Rec Rooms
REGULATORY BODIES				
41. Are your ships U.S. Flagged?	Some US	No	Yes	Some
(a) If not, what flag do they fly?	Liberia, Marshall Islands	Liberia		Liberia, Bermuda, Bahamas
42. Do you rely on reg body and Classification Society inspections in lieu of your own inspection and approvals?	Owner's Reps In-Yard	Owner's Reps In-Yd	Owner's Reps In-Yard	Owner's Reps In-Yard
(a) If you rely solely on regulatory body inspections, have you had any problems with this approach?				
43. Are your ships delivered and maintained in Classification?	Yes	Yes	Yes	Yes
(a) Which Classification Society do you use or have you used?	ABS and Lloyds	ABS, NKK	ABS	ABS
(b) Are all your ships classed with the same Society or do you use more than one Classification Society?	ABS and Lloyds	ABS, NKK	Not Discussed	All new are ABS
COST				
44. Do you develop cost estimates prior to negotiations with prospective builders?	Not Discussed	Yes	Yes	Yes
(a) What cost-estimating relationships do you use?		Not Discussed	Extrapolation	Not Stated
45. Do you consider "life-cycle" cost of the ship in your analysis of the offers?	Yes	No	No	No
46. When you buy a ship, how quickly do you expect to realize a return on investment?	Not stated	10-15 Yr Economic Ship Life	Not Discussed	Not Discussed
47. What, if any, cost savings do you realize by using foreign flag?	Approx $2-3 Mil/Yr	Approx $2 Mil/Yr	N/A	Not Discussed
48. Wh t are the largest cost contributors for operating U.S. flagged? (e.g., crew size, wages, USCG regulations, union rules, Environmental issues, etc.?)	Wages, Crew Size, USCG Regs, Pub Health	Crew Size, Wages, Union Rules	N/A	Not Discussed

APPENDIX 3

OWNER/OPERATOR SURVEY QUESTIONS - JUNE 1995

SOURCE SELECTION

1. How do you identify potential shipbuilding sources?
   (a) Do you conduct a market search?
   (b) Do you limit your choice of builders to a particular geographic area?
   (c) Have you ever worked with brokers to select a builder?

2. How do you select a shipbuilder?
   (a) Do you have a long-term relationship with a particular builder or builders?
   (b) What significant technical/management/business factors do you consider?
   (b) To what extent do you consider shipbuilder financial capability ?
   (d) Have you ever ordered a ship by telling builders what you would pay?
   (e) How does/will present US Government Regulations such as Title XI influence your selection?

3. How do you finance newbuildings?
   (a) Do you use corporate funding?
   (b) Do you work with banks? Partners? Brokers?
   (c) Do you use shipbuilder financing packages?

CONTRACT

4. How much time do you typically allow between requests for offers and signing of the contract?

5. Do you negotiate offers with builders regarding:
   (a) Technical details of the vessel?
   (b) Project management/in-yard inspection?
   (c) Detail cost items?
   (d) Bottom line cost only?

6. What type of payment terms, if any, do your contracts have?

7. Do you require any type of bank or corporate guarantees?

8. Do your contracts contain penalties?
   (a) For what items do you specify penalties?

9. How long a guaranty period do you require from the shipbuilder ?
   (a) Do you ever specify any special guarantees for engines or coatings, etc.?
   (b) Do you require a guaranty docking at the end of the guarantee period?
      (1) In the building yard?
      (2) Anywhere?

10. When buying a class of ships, do you order the lead ship with contract options for the follow-ships, or are all the ships ordered at the same time?

11. Are there any provisions in the contract to accommodate changes in Federal or International laws and regulations, e.g., EPA regulations?

12. Do you require a shipbuilder to provide office accommodations for your in-yard inspection personnel?

TECHNICAL

13. Do you use any type of transportation or cargo loadout models in your requirements determination?
    (a) If yes, are they your models or a consultant's models?
    (b) If no, how do you determine ship requirements?

14. What is your optimal size ship?
    (a) What are the most critical factors/assumptions underlying your answer?

15. Do you order ships using your own specifications or by using a shipbuilder standard design?
    (a) Have you tried either or both methods?
    (b) If so, what is your opinion as to the merits of either approach?

16. What process do you follow to develop a technical package stating your requirements?
    (a) Do you develop an Owner's Requirement, a design package or a Contract Spec?
    (b) How long does it normally take?
    (c) In-house or do you use a consultant?
    (d) Are there any special equipments or features you typically ask for?

17. What technical data do you typically require from the builder, e.g. drawings, studies, model tests, etc.?
    (a) With their initial offer?
    (b) Prior to negotiations?
    (c) With the contract specification?

18. Do you require builders to submit plans or other design products in any particular formats or standards?

19. Do you do plan approvals in-yard or in your own offices?
    (a) Do you use consultants for plan approval?

20. Do you require the vessel to be built in accordance with any specific regulatory or design standards in addition to SOLAS, MARPOL, OPA 90, and Class?

21. Do you ever specify particular vendors in your requirements or do you accept the builder's Maker's List?

CONTRACT ADMINISTRATION

22. What is your role after contract award?
    (a) In inspection, technical oversight, progress oversight, review/approval of dwgs?
    (c) How much authority is granted to your own in-yard personnel in approving changes and change orders?

23. How many people are typically dedicated to a project?
    (a) Full time, part time, skill sets (e.g., engineers, contract administrators, etc.).
    (b) On-site at the building yard?

OPERATIONS & LOGISTICS

24. How do you support/maintain your ships after delivery?

25. What are your maintenance philosophies (at-sea, pier-side, and during yard periods)?
    (a) Do you maintain any parts in inventory?
    (b) How do you determine what spare parts to buy and put aboard ship?
    (c) How do you identify the parts, get them ordered, and to the ship?
    (d) How do you address spares in the building specification, e.g. Class requirements only, maker's requirements, detailed list of specific types of components?

26. Do you have any plans/programs in place to standardize components or equipment across your fleet?

27. Do you develop operating and maintenance instructions for the ship or do you accept builder's and vendor's manuals?
    (a) Do you typically require any special operating manuals?

28. Is crew training provided for as a part of the building contract?

29. How are your ships crewed?
    (a) Officers?
    (b) Unlicensed?

30. Do you have women officers or crew on your ships?

31. How long are operating crews kept at sea?

32. How do you address "quality of life" for your crews?

REGULATORY BODIES

33. Are your ships US flagged?
    (a) If not, what flag do they fly?

34. How much do you rely on regulatory body and classification society inspections in lieu of your own inspection and approvals?
    (a) If you rely solely on regulatory body inspections, have you had any problems with this approach?

35. Are your ships delivered and maintained in classification?
    (a) Which classification society do you use or have you used?
    (b) Are all ships in your fleet classed with the same society or do you use more than one classification society?

COST

36. Do you develop cost estimates prior to negotiations with prospective builders?
    (a) What cost-estimating relationships do you use?

37. Do you consider the "life-cycle" cost of the ship in your analysis of the offers?

38. When you buy a ship how quickly do you expect to realize a return on investment?

39. What, if any, cost savings do you realize by using foreign flag?

40. What are the largest cost contributors for operating US flagged? (e.g., crew size, wages, USCG regulations, union rules, environmental issues, etc.?)

DAMAGE CONTROL ISSUES FOR THE 21ST CENTURY

HENRY (HANK) KUZMA
Damage Control Division
Naval Sea Systems Command
(SEA 03G1)

CLIFFORD B. CAMPBELL
George G. Sharp, Inc.

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The views expressed herein are the personal opinions of the authors and are not necessarily the official views of the Department of Defense or the Naval Sea Systems Command.

Abstract

Shipboard damage control, firefighting, and ship survivability equipment remained essentially unchanged with the exception of some improvements in fire fighting systems and agents since World War II. The war in the Falkland Islands and attack on the USS STARK were the first major incidents that raised the consciousness for the requirements to develop better damage control equipment, systems, and doctrine that would improve the survivability of Naval ships. Subsequent incidents magnified the need for rapid change. Over the past ten years, the improvements to the quality of damage control equipment and systems have made quantum leaps to protect and improve crew readiness. Today we have improved capabilities in personnel protection, dewatering, desmoking, and fire fighting portable equipment. Yet, with all these capabilities, if the current crews were reduced to 10-30 percent manning, these same ships and crews could easily be overmatched with relatively minor damage that could cascade into a catastrophic situation.

The problem? Economics dictate a major downsizing in the fleet size with respect to both the numbers of operational ships and the level of manning to support those ships. Automation in itself is not sufficient for the desired results. There must be complementary systems, sensors with built in selective automated actions, which combine the human interface to the degree that the ships maintain a readiness posture which make it survivable in any and all situations.

The solution. Future damage control systems, as we move into the 21st century, will be minimally manned and effectively automated to the point where damage control personnel, sensors and computer systems will provide for internal shipboard dominance to engage and overcome casualties from internal and external damage. These new ships will be survivable to all types of damage, whether inflicted in hostile environments or accidental situations. Future damage control systems, equipment, and personnel must be able to detect, assess, engage, control damage, and reestablish internal shipboard dominance over the casualty. To that end, not only must the ships operational systems must not only lend themselves to minimal manning, but damage control systems and equipment too, must be tailored and automated through innovation so they are complementary to the level of manning necessary to support the ships daily operations.

List of Figures

Abbreviations

AEL	Allowance Equipage List
ATG	Afloat Training Group

DAMAGE CONTROL ISSUES

CBM	Condition Based Maintenance
COTS	Commercial Off The Shelf
CSOSS	Combat System Operating Sequencing System
DCA	Damage Control Assistant
DCS	Damage Control System
EOCC	Engineering Operating Casualty Control
FTG	Fleet Training Group
LAN	Local Area Network
ROC	Required Operational Capabilities
POE	Proposed Operating Environment
PPT	Portable Personnel
PQS	Personnel Qualification Standards

T

Introduction

Today's ships and those of the future are faced with changing environments and technical improvements of weapons which makes the "survivability" problem a much more complex equation. Increasingly, there exists the threat of smart and ever more sophisticated weapons which can be delivered with pin-point accuracy: in addition we face an enemy from

Damage control technology must remain on the leading edge of these transitions. We cannot afford the losses in dollars, personnel, and availability of our ships. Shear heroic action will not save the day to the extent it has in the past. The amount and kinds of manpower required will not be available. Gone are the days when we could expect that problems would be detected by a man on the

advances will help alleviate a catastrophic situation from being overmatching.

Internal Shipboard Dominance

The Navy is considering several designs for its ships of the future. All will be built with the goal of putting "Ordnance on Target." These ships are taunting Battlespace Dominance, systems with a primary mission of inflicting maximum damage upon the enemy. However, should our self defenses not react in time or crew, Current and the initiatives including the "SMART SHIP" concept, is looking at how to reduce shipboard manning while maintaining our warfighting capabilities ability to "live and fight" another day. Figure 1 provides a framework that recognizes Damage Control / Survivability as a major factor in manning and also the central impact area that must be addressed when reducing our shipboard manning requirements. In effect damage control is "Internal Dominance".

Damage Control Functions and Procedures

Damage control closely interfaces with survivability, safety, and casualty control. Damage control starts prior to damage. The material conditions of the ship and its spaces must be maintained and all equipment in proper working condition. To ensure a ship will be survivable, the following must be considered:

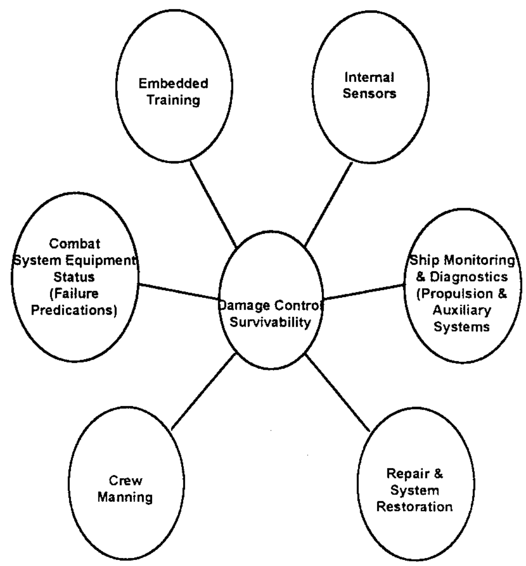
Preparation

Preparation includes all preliminary measures taken to prevent, minimize, localize, and combat damage. Preparation includes the following functions:

- Preserving stability and reserve buoyancy
- Maintaining watertight integrity
- Minimizing fire hazards throughout ship

only partially stop the threat, then the ship must revert to basics and rely on its "Internal Dominance." This internal dominance will be a combination of sensors, HM&E/Combat systems monitoring, controls and failure prediction systems. These smart systems will be required due to manning constraints current being reviewed by the Navy. Manning reductions have and will continue to present a significant problem for today's fleet. The Navy is reviewing within its lifelines reduction to a ships

- Maintaining a high degree of cross training for the entire crew
- Proper maintenance of fire protection /damage control equipment



**Internal Shipboard Dominance
Figure 1**

Detection

Detection is analogous to early investigation and damage is almost invariably more extensive than a cursory examination would indicate. The degree of investigation and/or detection required immediately after a ship has been damaged depends upon many factors. Certain information relative to the extent of the casualty will be available almost

immediately. For example, heavy smoke and whipping of the hull structure may indicate a major underwater explosion. All reports to the DCA are combined with sensor information to bound the extent of damage problem.

Timely detection of fire, flooding, and hull damage are critical in ship survivability as the ship may be lost due to the cause of any of these factor.

Probably the hardest to detect and identify is the extent of flooding and hull damage which will effect the stability and reserve buoyancy of the ship. Stability and reserve buoyancy criteria are based on World War II experience. The reserve buoyancy standards applied to Naval ships are: Ships under 100 feet in length must be able to survive flooding of two compartments; combatants over 300 feet must be able to survive damage of a length equal to 15% of the ships length (12.5% for non-combatants). Stability standards applied to Naval ships define, for wind and roll, for off-center weights, and for high speed turns,

- personnel exit a hazardous area in the event of a casualty, and or find medical.
- Proper stowage of damage control equipment
- Damage control equipment dispersed throughout the ship in each function area.
- Fire insulation
- Fire resistant paint
- Fire suppression systems

The passive damage control features are important as they help the ship function under a casualty situation by extending the window for reacting to the damage and maintaining the gear in top notch condition so that it works every time, the first time.

Reporting

When a casualty is detected it must be reported so the appropriate damage control action can be initiated. The report may come over the ships internal sensors, internal phones, wireless communications, by a sound powered phone, or by message runners.

limits of, respectfully 15 deg (damaged), 15 deg; and 10 deg on initial heel angle; 0.6 (intact), 0.6, and 0.6 on the ratio of initial maximum righting arm; and minimum 40%, 40%, and 40% "dynamic" righting energy reserves.

Using these standards effectively today and in the future is a necessity as they represent the focal point for ship survivability and mastering "Internal Dominance". The capability to automatically calculate and measure these factors MUST be a function of our damage control systems of the future.

Passive Damage Control

Passive damage control are features built into the ship and all actions that assists the ships crew in the performance of their duties as it relates to damage control. Included is this category are:

- Conducting more effective maintenance
- Photoluminescent marking system to help

However the report is initiated, the most important fact is that it pin-points the damage and reaction time is reduced. The reduction of manpower requires all crew members be sensors and that all the installed sensors work and thereby, support the manpower reduction initiatives being sponsored by the Navy.

Displaying how the damage is given to the human interface is just as imortant as the information. Common display features must be identified and maintained in the future Damage Control Systems.

Containment or Isolation

A great many ships have been sunk during battle action and very few of them have gone down as a direct result of initial damage. Most of them have gone down hours later as a result of rapid progressive flooding, fire, collapsing bulkheads, increased free surface or human error. Had flooding and fire boundaries been established when and where it was possible to do so, and had the damage

been confined to its original area, even though it may be large, many of those ships would still be afloat and able to fight. The moral is : HOLD WHAT YOU HAVE. Do everything possible to prevent progressive flooding and smoke spread. To contain the problem, all six sides of a fire and watertight subdivisions are required to be manned, in essence box the damage and limit the amount of damage . Once the damage is boxed, then the ship may begin to restore her warfare fighting capability.

Automation of containment is difficult as the exact location of the damage must be determined. Accurate fixed and portable sensors and flexible repair parties are the key to mastering this function of damage control. Sensors that indicated a leak or hole in the system would aid in the isolation. In addition, closing of automated valve operators in vital systems once the location is known will greatly minimize damage growth. Sensors that indicated a leak or hole in the system would aid in the isolation. Portable sensors would provide additional information needed to isolate a problem.

Combating the casualty

Once damage has been inflicted, it must be localized and minimized. This is done by controlling flooding, dewatering, fire fighting, desmoking, and rendering first aid to injured personnel. This is the one functional area that reduction of manpower is not effective. A little considered fact is that Damage control is an offensive as well as defense function. The ship's ability to inflict punishment on an enemy or destroy him, or to perform any other mission, may depend on the success of combating the ships own casualty. It is essential that all hands in the ships company recognize their responsibilities and that each one of them is damaged control PQS qualified in damage control and to have the necessary knowledge, skills, and teamwork to take effective actions.

Restoration of Vital Services

Vital systems are those systems which are designed to have the ability to maintain a units mobility, offensive and defensive power, including the ability to control fire, flood, and hull and armament damage. They include propulsion and auxilary machinery, electrical power, lighting, interior and exterior communications, ship's fire control system, firemain supply, chill water, and HP/LP compressed air systems.

The casualty control organizations are established within the framework of the Battle Organization. Damage control supports casualty control through the isolation of damage with subsequent restoration when alternate means of restoration is not routinely available. Currently damage control repair parties under the DCA are the offensive teams to control fire, flooding, and structural failure. The first line of defense are installed fire protection and drainage systems. Functionally, the Repair Party/DC teams maintain operation of vital systems, investigate damage reports, and make emergency repairs to return systems and equipment to operation.

The casualty control functions are accomplished by the engineering and combat systems personnel and initiate all casualty control procedures using EOCC and CSOSS, determine need for damage control actions, and assign experienced repair personnel to restore the casualty.

The ships mission and, to some respects, the battle scenario will be important variables that must be factored into the damage repair prioritization. The Command and Control organization must prioritize the restoration process to ensure mission capability is returned first. The DCA supports the restoration process by re-priortizing the support needed to support the Comand and Control requirements.

Enhancing Platform Systems

Sensors

From a damage control perspective, sensors are required for the following functions and must support detection, reaction, prediction, and restoration:

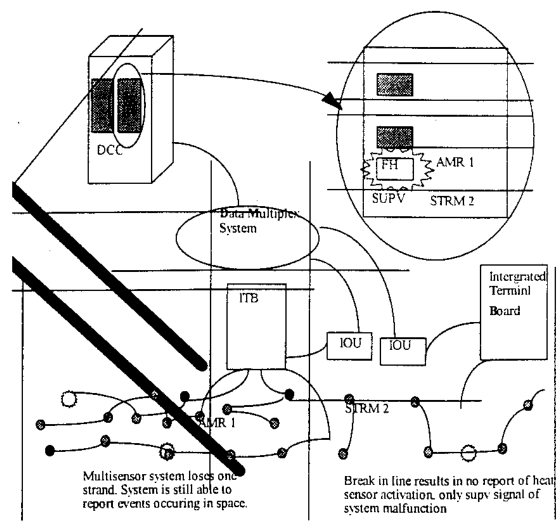
- Fire/smoke
- Flooding
- Structural Integrity
- Hatch/Door Closures
- Ventilation integrity

The intent of the sensor is to be an extension of the men remaining in the Damage Control Organization.

The detection of damage can be performed by people or installed sensing equipment. People use several means to detect damage including eyes, ears, touch, kinesthetic cues (i.e. motion). Although it is difficult to describe man's sensing ability in a meaningful quantitative manner, for most instances of detecting damage a gross description of man's capabilities is made. An advantage to using personnel as a detector of damage is that the personnel are mobile and have built-in processing and decision making capability. Thus, the personnel can make some immediate response to damage and, at the same time, transmit some manner of processed information to another location. In addition, the personnel can minimize / correct the damage or request additional manpower assistance if available.

Installed sensors do not inherently show adaptability to situations. Depending on their type and construction, sensor vulnerability may exceed that of man. As a general rule, current sensors are not reliable. Therefore, in substituting sensors for men, consideration must be given to placing an additional number of types of sensors in a given compartment to resist damage.

DC SENSOR SYSTEM



DC Sensor System
Figure 2

In the area of sensing, every crew member is a sensor of damage. This fact does not change, even with the installation of fixed sensors. To permit reduction of the crew, greater levels and numbers of installed sensors will be required. Figure 2 provides a block diagram of how the DC Sensor System could be set up. It shows the survivability of sensors when multi sensors are used in a compartment.

When considering the installation of sensors aboard ship three objectives come to mind:

- Enable personnel to escape danger.
- Initiate prompt damage control operations to limit damage to extent practicable.
- Reduce the number of personnel.

To futher enhance the human personnel sensor capability portable sensors are required in the damage control arena to identify the extent of the damage. With the reduction of manpower the classic investigation function will be altered requiring the man to be a delivery system for improved internal sensors. The smart sensor technology will need to be able to link to Command and Control stations in one of three ways:

- Locally at the scene

- Area control to the repair station or
- Data linked via the LAN network to DC Central for tactical information.

An overall systems approach for the status display of fire, flooding, closures, intrusion and damage is required. Sensors are an integral part of automating the damage control functions. Mimic displays are required as well as audible alarms. The Navy is using the Damage Control System (DCS) to enhance the curent damage control consoles and improve damage assessment within he machinery controls that are linked to the ships Command and Control.

Ship Monitoring and Diagnostics

To effectively monitor the ship for damage and proper operation the ship monitoring devices need to be integrated to asses damage control functions, status of combat systems and the hull machinery and electrical equipment. In essence a comprehensive monitoring system that crosses all functions and missions of the ship is required existing CBM sensors can assist in this requirement.

In addition technologies need to be advanced that provide real time fire, flooding, and smoke spread. These ship monitoring systems will be cooperative and mutually interactive to provide a tactical picture.

Controls

To decrease reaction time to alarms and possible damage, redundant control over the firemain, ventilation, vital HM&E and damage control systems with additional remote control valves is required. Control of these valves must rest with the Engineer, DCA, and Combat Systems Officer (CSO). Centralized monitoring of alarms and remote controls are required for the following systems:

- Fire suppression systems
- HM&E systems; including the chill water system and ventilation
- Vital Damage Control systems
- Machinery Control systems.

In order for the internal shipboard dominance to be effective, a Damage Control Operating System (DCOS) is required in the future. This system would be much like EOSS and CSOSS that is used to control a casualty in engineering and combat systems. DCOS would be comprised of the following:

- Decision tools
- Equipment layout, setup and use
- Repair Party Actions (RPA) which would include tactics and techniques
- Endurance, i.e. number of personnel required

The system would be automated and assessible via the LAN. This assists the Command and Control of the casualty and helps reduce requirements. In addition the system could be used to enhance crew readiness by using "embedded training."

Communications

To effectively communicate the location and isolation of vital and non-vital systems the following systems are required onboard Naval ships:

- Ships internal phone system.
- Wireless communications
- Sound powered DC circuits
- Computer aided decisions.

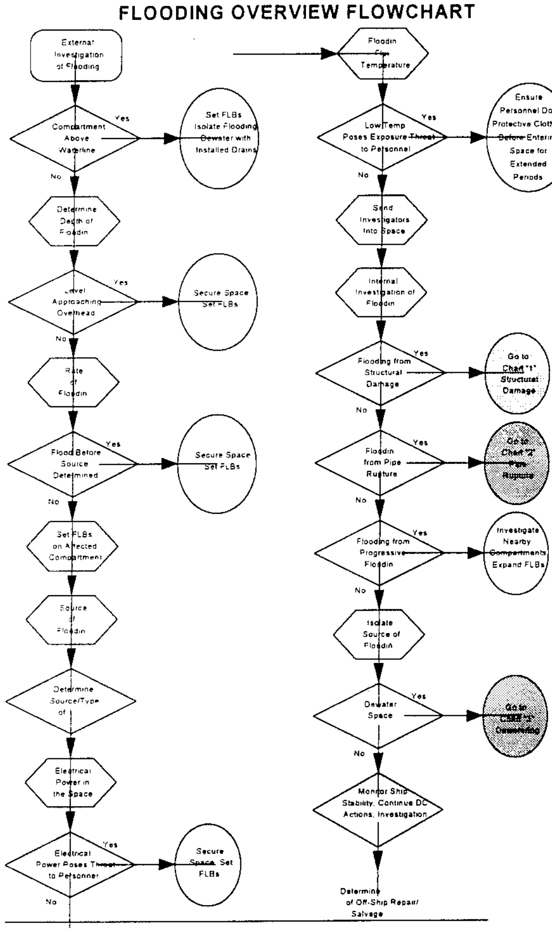
These systems provide for the rapid dissemination of information and are vital to automating the damage control arena. Figure 3 provides one decision making aid that is being developed through recent Damage Control R&D efforts. This example is one of many being developed in each of the functional areas of damage control. Decision aids when incorporated into "Expert Systems" can expedite the thought process and lower the reaction time in a casualty.

As technology increases, the requirement to man the damage control repair stations may

be significantly reduced. In effect DCC becomes the centralized tactical action station. From a damage control systems standpoint the communications net must be automated to access automated casualty procedures that are available on the LAN and tactics for employment to assist in minimizing the casualty growth. This information must be assessable via the DCS system and include the following:

- Firemain
- Ventilation
- Atmospheric conditions
- Dewatering
- Repair/restoration functions

FLOODING OVERVIEW FLOWCHART



Flooding Decision Tree
Figure 3

Another communication requirement would be the use of a Man on the Move (MOM) technology. With limited assets available to dedicate to the damage control problem, the location and utilizaiton of the personnel becomes more important. A Portable Personnel Tracker (PPT) eliminates the need for constant communications to the personnel. The PPT in conjuction with the installed sensors would provide a tactical picture. These two systems would interact to show progress in combating the casualty. The PPT will also utilize a wireless communication cellular phone and advanced pager type system to communicate to DCC.

Failure predictions

Failure prediction today is non existent in the realm of damage control. However, today's technology can provide failure perdition tools that pin-point the damage and lower the reaction time. The following features need to be designed and integrated into shipboard systems:

- Location and extent of progressive flooding
- Location and extent of Structural holing
- Location and extent of pipe rupture

Crew Support

Damage control is an all hands evolution and the Executive Officer (XO) needs to be designated as the Survivability Officer. This designation would promote the ships ability to work together and help alleviate the infighting for OPTAR dollars. The XO would be responsible to the Commanding Officer for all survivability issues. This would include all area of training, and material readiness required to maintain the overall war fighting capability of the ship.

Distributed stowage of damage control equipment, coupled with personnel, is required on all ships to reduce the reaction time and to provide the crew with the tools to effectively control a casualty with minimal reaction time. Distributed damage control equipment supports the reduced crew concept

by providing survivability equipment throughout the ship.

The alcoving of the equipment needs to be designed into the ship. The new LPD-17 has accomplished this and mantained the passageway clearences required. The alcoves have also been designed in a modular nature so that stowage brackets can be easily changed should new equipent be outfitted.

In addition the distributed stowage allows the current and future ships to reduce manning by also distributing the personnel, thus reducing their vulnerability while maximizing effectiveness and minimizing response time.

Training

The current goal as outlined by the Office of the Chief of Naval Operations (OPNAV) is to move training afloat, however, ships are not currently equipped to handle the additional training burden. Ships are having difficulty meeting existing training requirements. Due to recent change in training philosophy, the emphasis of the ATG/FTG shipboard training teams has moved to a "train the trainers" approach, where the training is provided only for selected members of the ship's own casualty / damage control training teams. As a result, the overall damage control burden has now been placed on the ship's crew.

allow key personnel to practice casualty/damage control competencies and would raise their knowledge level before integrated shipwide drills are conducted. The software should be available via the LAN and will be available on a portable computers. The portable concept allows the embedded training to leave the classroom where it can be used to support hands-on equipment training.

Damage Contol Integrated Logistic System (ILS)

The concept to "train as you would fight" cannot realistically take place if senior personnel are removed from their General Quarters watchstation to man training teams. Although the requirement to conduct shipwide integrated survivability drills exists, it is extremely difficult to coordinate and implement such drills using only ship's force personnel as the drill planners, drill initiators, and drill evaluators while retaining qualified personnel to act as the training subjects. This problem is compounded when we reduce the size of the manning aboard ship.

With the reduction of the crew size the remaining repair station personnel need to be the "damage control experts". The training of the crew can be approached in a five step solution consisting of:

- Embedded training
- Practical application of the damage control tools and equipment for the repair station personnel
- Casualty utilization of system training for reconfiguration
- Personnel manning qualifications
- General crew damage control training for the remainder of the crew to know how to contain and isolate the damage.

Another approach to improve fleet training effectiveness is to provide computer-based interactive "team training in integrated casualty/damage control procedures" to the watchstanders before the ship conducts shipwide drills. "Embedded Training" would Finially, in order for these concepts to mature the ILS must also remain on the leading edge to complement readiness, sustainability, and maintenance. This can be accomplished via automation and advancing the software and hardware utilized with respect to sensors and damage control equipment.

Reduction of manpower for damage control equipment maintenance would be accomplished by the following actons:

- Maintain standardized damage control AEL's

- Establish fleet team to identify shortfalls and excess equipment
- Bar code all damage control equipment for maintenance requirements and location
- Establish shore based refurbishment and distribution facilities that are owned by the Fleet
- Provide DC/HT billets for the shore based facility to improve hands-on rate training while refurbishing equipment
- Continue utilization of COTS with the ability to quickly outfit entire fleet

Effects of Upgrading Platform Systems

The result of upgrading sensors and damage control computer aided enhancements will be the more efficient use of onboard personnel. In effect reducing the number of personnel required to contain, isolate, and restore a casualty.

Conclusion

Despite the successes to date of the damage control organization in combating damage, it will be some time before the full effect of advanced technologies with reliable sensors are fully integrated into shipboard systems and the systems begin to show significant savings. Internal shipboard dominance and utilization of the damage control organization will manifest itself into real savings in the short term. An analogy can be made for reduced manning to what the House Speaker Mr Gingrich has said recently about the US Government budget process, "When you change the budget, you've really changed government. And until you change the budget, you've just talked about changing government." Reduced manning is the same, until you've really changed the numbers on the ship nothing has changed. However, to accomplish this task requires more than a strong commitment, it requires a cultural change and how we perceive Risk Management.

Summary

A review of the damage control equipment, techniques, and shipboard systems on current and future classes of ships leads to the following conclusions:

- Distributing personnel within the ship and reduction of personnel is achievable.
- There has been little or no impact on reducing personnel assigned to damage control duties as a result of current installed systems
- Damage control ILS is critical in maintaining war fighting capabilty and increasing efficiencies in repair party personnel by increasing realiability and shorebased hands-on maintenance training. In addition, damage control equipment would be standardized, increasing rate training and efficiencies
- Ships of the future, designed with reduced manning, will not be able to rely solely upon installed damage control systems to compensate for the lack of personnel to combat damage.
- Quick knowledge of location and type of damage would allow for more flexible assignment of personnel which would reduce the number of personnel dedicated at each repair station.
- A Repair Party Action system is required to access the LAN onboard ship for efficient utilization of repair party actions.
- Communication requirements should include a Portable Personnel Tracker system.
- Topside personnel must be utilized to combat damage if weapons and \ or electronic sensor systems were inoperative. However, rapid knowledge of overall ship status is required to allow a judgement on personnel availability.
- The requirement for a rapid, accurate, and flexible response would impose a burden on the training required for damage control. This requirement can be met, but a top down review of the ROC / POE relative to the damage control organization is required.
- Research and Development must continue in the field of practical damage control, as

well as improving sensor technology and computer interfaces.

Acknowledgments

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Henry (Hank) Kuzma *is a graduate of the US Naval Academy with a BS degree in Management Technology. He served in the Navy as a Surface Warfare Officer. He is presently working for the Naval Sea Systems Command in the Fire Protection and Damage Control Group, SEA 03G*

Clifford B. Campbell *is a Senior Engineer with George G. Sharp, Inc. A former Naval Surface Warfare Officer, he holds an MS degree in Engineering Management. He is presently head of the Damage Control / Survivability Group at George G. Sharp, Inc.*

INFLUENCE OF HUMAN ENGINEERING ON MANNING LEVELS AND HUMAN PERFORMANCE ON NAVY SHIPS

DAVID E. ANDERSON
FRED R. OBERMAN
Human Systems and Reliability Engineering Division
(SEA 03D7)
Naval Sea Systems Command

THOMAS B. MALONE
CLIFFORD C. BAKER
Carlow International

The views expressed herein are the personal opinions of the authors and are not necessarily the official views of the Department of Defense or the Naval Sea Systems Command.

Abstract

The objectives of Human Engineering (HE) are generally viewed as increasing human performance, reducing human error, enhancing personnel and equipment safety, and reducing training and related personnel costs. There are other benefits that are thoroughly consistent with the direction of the Navy of the future, chief among these is reduction of numbers of personnel to operate and maintain Navy ships. The Naval Research Advisory Committee (NRAC) report on Man-Machine Technology in the Navy estimated that one of the benefits from increased application of man-machine technology to Navy ship design is personnel reduction as well as improving availability, effectiveness, and safety.

The objective of this paper is to discuss aspects of the human engineering design of ships and systems that affect manning requirements, and impact human performance and safety. The paper will also discuss how the application of human engineering leads to improved performance, and crew safety, and reduced workload, all of which influence manning levels. Finally, the paper presents a discussion of tools and case studies of good human engineering design practices which reduce manning.

List of Figures

Notations/Definitions/Abbreviations

AAW - Anti-Air Warfare
ACDS - Advanced Combat Direction System
AI - Artificial Intelligence
ASTAB - Automated Status Boards
ASUW - Anti-Surface Warfare
ASW - Anti-Submarine Warfare
CAP - Carrier Air Patrol
CCA - Carrier Controlled Approach
CNA - Center for Naval Analysis
CIC - Combat Information Center
COD - Carrier On-board Delivery
COMNAVSEA - Commander, Naval Sea Systems Command
CV - Aircraft Carrier
DoD - Department of Defense
EW - Electronic Warfare
FY - Fiscal Year
HE - Human Engineering
HRED - Human Research Engineering Directorate
LSO - Landing Signal Officer
MPT - Manpower, Personnel and Training
NRAC - Naval Research Advisory Committee)
PRI-FLY - Primary Flight Control
SIMWAM - Simulation for Workload Assessment and Modeling

Background

In 1985, the Commander, Naval Sea Systems Command (COMNAVSEA), established a policy to incorporate human factors requirements into the design and acquisition of naval ships, ship systems and equipment. Human factors were defined as the activities required to integrate the human operator and maintainer into a total ship, ship system, or equipment. Human factors were subdivided into three major categories: 1) human engineering, which is concerned with the analysis, design, and test and evaluation of total ship platform, systems, and equipment to ensure that people can effectively operate and maintain them; 2) life support engineering, which is concerned with design, system safety, personnel protection, and environ-

mental control; and 3) manpower, personnel and training (MPT), which is concerned with the requirements, prediction, selection, training, and assignment of personnel to operate and maintain the total ship platform, systems, and equipment.

The need to reduce manning on ships

The Navy ship constitutes one of the most complex weapon systems in the US defense arsenal. It is a multi-personnel system with complements of up to 6,000 conducting multiple operations (e.g. air warfare, shore bombardment, surface warfare operations, search and rescue operations, etc.) in multi-warfare environments (AAW, ASW, ASUW, EW and strike). It can operate as an independent combatant, member of a squadron, or as an element of a battle force. The demands human engineering places on a ship design are unique in the breadth of their scope and the depth of requirements.

The surface and subsurface ship systems employed in the fleet today, and those being designed for the fleet tomorrow, make severe demands on the readiness, performance effectiveness and physical capabilities of personnel who must operate and maintain them. These systems are complex and extremely demanding on the sensory, motor and cognitive skills and decision-making capabilities of personnel. Add the increasing capability of the threat, the need to conduct multi-warfare scenarios, and the need to integrate, coordinate and interpret data from multiple sources and it becomes evident that we are rapidly approaching the limits of human capacity and capability.

The expected operating environment of the next generation of naval systems will impose extreme information loads on the personnel responsible for operating and maintaining shipboard systems. The complex combination of systems, equipment and personnel and requirements for rapid planning, scheduling and deployment of mission elements in the naval environment may converge to impose an untenable workload on the human operator. Cognitive workload will continue to be particularly high for shipboard personnel due to a variety of interdependent elements, including increases in the number and rates of decisions which stem from increases in the complexity and quantity of data that must be processed. Traditionally, such increases in workload have been compensated for by commensurate increases in manning. However, current and projected budgetary constraints coupled with demographic data projecting a continuing reduction of military-aged people over the next 20 years, reduce the feasibility of this solution. The requirement to reduce the manning levels of new military systems as compared with predecessor systems is becoming a fact of life. Projected DoD budgets demonstrate a definite trend toward reduced manning. CNA analyses have shown that a significant reduction in manning is one of the most important factors in the affordability of new technology ships and systems. The overall importance of optimized manning has been recognized at the highest levels within the Navy and has led to such efforts as the CNO's "Smart Ship Project" and requirements for the SSN 21 attack submarine to be manned at almost 25% below that of its predecessor. Similar efforts are underway to reduce manning on SeaLift and commercial maritime ships. The Strategic SeaLift Technology Development program within NAVSEA is examining the issue of reduced manning as a means to achieve international competitiveness.

Human Engineering

To achieve effective integration of personnel into the design, engineers must apply human engineering during development and acquisition of military systems and equipment. A skillfully applied human engineering effort will develop or improve the man-machine/software interfaces and achieve desired human performance effectiveness during system operation, maintenance and control. It will also make demands on personnel resources, skills, training and costs. The human engineering effort should include, but not necessarily be limited to, active participation in the following three major interrelated areas of system/equipment acquisition: research and analysis, design and development, and test and evaluation. This paper will only concentrate on human engineering in analysis and design and development.

Human engineering issues in the reduction of ship's manning

The underlying rationale of the human engineering strategy for manning reduction involves applying human engineering (HE) and artificial intelligence (AI) techniques to reduce the physical and cognitive workloads imposed on shipboard personnel. This permits workload redistribution between machines and people and among crew members. It fosters consolidation of existing operator positions, simplification of operator tasks, and reduction of overall ship manning levels. NAVSEA has only formally used automated human engineering analysis tools for manning reduction in recent years. However, engineers have demonstrated the potential for reducing manning through improved task simplification and improved man-machine interface design in a number of other applications.

The central human engineering issues in manning reduction are the allocation of functions to man or machine, establishing and defining the role of man in the system and allocating optimum workload to maximize human performance. Function alloca-

tion is based on an assessment of the differential capabilities and limitations of men and machines in terms of the requirements of a specific function. There is an increasing need for interactive dialogue between humans and computers in automated systems. It underlines a requirement to consider the interactions between man and machine because few operations are either purely manual or totally automated; most are "semi-automatic". The role of man in automated operations is as activator, monitor, manager, and under certain circumstances, as the intervening decision maker, taking over control from the automated process. The role of man is situationally dependent.

With these considerations in mind, it is apparent that the active focus of human engineering must be on determining the role of man in the system, rather than merely allocating functions to human or machine performance.

Another critical issue in applying human engineering analysis techniques to manpower reduction is the relationship between manning and workload. The basis for predicting manning requirements must be the workload associated with the roles of humans in system operations. The challenge for the human engineering profession lies in workload measurement. Workload measures and methods being sought involve human sensory, psychomotor, perceptual, and cognitive capacities and the demands placed on these by operator tasks. The greatest uncertainty lies in the area of defining cognitive and decisionmaking workload. One of the problems is that cognitive and decision making workload is not directly observable. Operator speed and accuracy is observable, however, and can ultimately contribute to or degrade total system performance. Time and accuracy in responding to events will influence total system performance. Workload (underload or overload) must be inferred from observed performance.

A number of measures and techniques for assessing workload have been proposed, including:

- Analytical methods
- Subjective measures
- Secondary task measures
- Physiological measures
- Human Information Processing Models

Human Engineering Design Techniques to Reduce Manning

The major techniques to reduce ship's manning through human engineering design include 1) application of human engineering design principles, standards and methods; 2) determining strategies for task simplification; and 3) developing decision aids and performance aids. The first two techniques are process-oriented. They are concerned with workload and manning reduction through the application of human engineering design processes. The third technique is product-oriented in that it involves aids provided to the operator or maintainer at the respective worksite.

Application of human engineering design principles, standards and methods

Human engineering principles, standards and methods for improving the design of ship systems encompass the design 'ilities':

- operability,
- controllability,
- manageability,
- usability,
- maintainability,
- sustainability,
- survivability,
- safety,
- habitability,
- installability,
- reconfigurability,
- upgradeability, and
- supportability

of ship systems. Given the task sequences to be performed and the demands that individual tasks and task sequences make on personnel, the requirement to enhance ship systems design, equipment development, software programming or acquisition, procedures development, information management, control of environments and people-centered arrangements remains.

The results of applying human engineering in design are:

1) displays which are meaningful, readable, integrated, accurate, current, complete, clear, uncluttered, readily associated with control actions and other related displays, and responsive to information requirements;

2) controls which are reachable, identifiable, operable, consistent, compatible with expectations and conventions, and simple to use;

3) consoles and panels which include the required control and display functions which are arranged in terms of functions, sequence of operations, and priorities;

4) procedures which are logical, consistent, straightforward, and provide feedback;

5) communications which are standardized, consistent, intelligible, clear, concise, identifiable, prioritized, and available; and

6) environments which are within human performance, comfort and safety limits, designed in terms of task requirements, and consider long term as well as short term exposure.

Human engineering decision aiding approaches for manning reduction

Decision-aiding approaches involve applying Artificial Intelligence (AI) technology to achieve "synthetic force multiplication". Such multiplication would be achieved by allowing selected functions to be reallocated to computers. The approach is to employ AI techniques to develop a series of decision aids to reduce the cognitive workload of ship personnel, permitting fewer operators to handle a greater workload. This would allow designers to consolidate present positions, thereby reducing overall ship's manning levels.

The concept of applying AI technology to ship operations is not new. Systems which employ AI technology are currently under development in the area of decision support for command and control. Thus far, the general approach has been to provide decision makers with an AI system that performs data fusion or synthesis. Data fusion refers to the process by which data from a variety of sources are correlated, integrated, and abstracted to present a highly refined characterization of an event, process or situation. Properly implemented, these systems have the potential to reduce the amount of information the human must process in order to make a decision, and consequently to reduce workload. Although these systems have the potential to reduce workload, the actual reduction in manning to be realized through their implementation has been relatively small. This is due to the fact that most of these systems are being developed for upper level decision makers who, by simple virtue of their lesser numbers and command responsibilities, have little effect or are not candidates for manning reduction. Lower level decision makers, such as sonar operators and boiler technicians are greater in number and have greater potential for manning reduction, though they are only now being considered for automated decision aiding.

Human Engineering Process for Manning Reduction

The methods used by the human engineering specialist can best be described in the context of a human engineering design process of which the HE tools comprise essential components. The human engineering process for ship system manning reduction is presented in Figure 1.

The human engineering process proceeds from a front-end analysis of requirements and constraints to a determination of the alternate roles of man in the system. These candidate role-of-man concepts are assessed through workload simulation and, based on the results of the simulation exercises, an optimum role-of-man concept is selected. The role-of-man concept then drives the establishment of the reduced manning concept. Human engineering design principles, standards and methods are then invoked to produce a design concept that implements the manning reduction approach, and the design concept is simulated or mocked-up and assessed through empirical evaluations.

Human Engineering Front-End Analysis

Front-end analysis is a critical element in any application of human engineering. Essentially a human engineering front-end analysis focuses on the identification, analysis and integration of requirements which will comprise the basis for human engineering design concepts and design criteria. Front-end analysis from a human engineering perspective provides the groundwork for all later man-machine interface design decisions. The process underlying a generic human engineering front-end analysis is depicted in Figure 2. Human engineering front-end analyses techniques may also be found in DoD-HDBK-763.

Design and development of the system equipment, software, procedures, work and environments associated with the system functions requiring personnel interaction should include a human engineering effort. This effort converts the mission, system and task analyses data into detailed design or development plans. These plans create a man-machine interface that will operate within human performance capabilities, meet system functional requirements, and accomplish mission objectives. The final developed design is the culmination of the initial planning, system analyses, criteria and requirements application and engineering effort.

The activities and requirements associated with each step of the human engineering front-end analysis are described below:

Mission Analysis

Mission analysis can be developed from a baseline scenario, i.e., given the multitude of options for employment of a military system, what sequence of events is most likely to require the system under consideration to be used. Mission analysis seeks to define the system objective in terms of human capabilities and limitations. Parameters most important to mission analysis are those which define the environment(s) in which both man and machine will operate. For instance, human beings do not operate very well in extremely low or extremely high temperatures unless they are assisted by devices which lower or raise the close-proximity temperature to an acceptable level. However,

some computers operate extremely well in controlled, low temperature environments and certain propulsion systems operate well in elevated-temperature environments. Mission analysis sets the framework for the follow-on effort which will adapt the system and the environment to allow the human to perform optimally.

Function Analysis and Allocation

Human Engineering principles and criteria must be applied to specify man-machine/software performance requirements for system operation, maintenance and control functions and to allocate system functions to 1) automatic operation and maintenance, (2) manual operation and maintenance, or (3) some combination thereof. Function allocation is an iterative process which determines the level of detail appropriate for the level of system definition.

Information Flow and Processing Analysis - Analyses can be performed to determine basic information flow and processing required to accomplish the system objective and include decisions and operations without reference to any specific machine implementation or level of human involvement.

Estimates of Potential Operator/Maintainer Processing Capabilities - Plausible human roles (e.g., operator, maintainer, programmer, decision maker, communicator, monitor) in the system must be developed. Estimates of processing capability in terms of load, accuracy, rate and time delay must be prepared for each notional operator/maintainer information processing function. These estimates should be used initially in determining allocation of functions and should later be refined at appropriate times for use in defining operator/maintainer information requirements and control, display and communication requirements.

Allocation of Functions - From projected operator/maintainer performance data, estimated cost data, and known constraints, the system developer conducts analyses and makes tradeoff studies to determine which system functions should be machine-implemented and/or software controlled and and/or reserved for the human operator/maintainer.

Equipment Selection - Human engineering principles and criteria are applied along with all other design requirements to identify and select the particular equipment to be operated/maintained/ controlled by personnel. The selected design configuration will reflect human engineering inputs, expressed in quantified or "best estimate" terms, which satisfy functional and technical design requirements. The selection will also ensure that the equipment meets the applicable criteria contained in ASTM F 1166 and other human engineering design guidance documents.

Gross Analysis of Tasks - Human engineering principles and criteria must be applied to analyses of tasks. The analyses will provide one of the bases for making design decisions; e.g., determining whether system performance requirements can be met by combinations of anticipated equipment, software, and personnel, and assuring that human performance requirements do not exceed human capabilities. These analyses can also be used as basic information for developing preliminary manning levels; equipment procedures; skill, training and communication requirements; and as Logistic Support Analysis inputs. Those gross tasks identified during human engineering analysis must be further analyzed as critical tasks. These tasks are those performed on end items of equipment which humans operate and maintain and which require critical human performance. They are also candidates for possible unsafe practices or are subject to promising improvements in operating efficiency.

Analysis of Critical Tasks - Further analysis of critical tasks should identify: (1) information required by operator/maintainer, including cues for task initiation; (2) information available to operator/ maintainer; (3) evaluation process; (4) decision reached after evaluation; (5) action taken; (6) body movements required by action taken; (7) workspace envelope required by action taken; (8) workspace available; (9) location and condition of the work environment; (10) frequency and tolerances of action; (11) time base; (12) feedback informing operator/maintainer of the adequacy of actions taken; (13) tools and equipment required; (14) number of personnel required, their specialty and experience; 15) job aids or references required; (16) communications required, including type of communication; (17) special hazards involved; (18) operator interaction where more than one crew member is involved; (19) operational limits of personnel (performance); and (20) operational limits of machine and software. The analysis must be performed for all affected missions and phases, including degraded modes of operation.

Workload Analysis - Individual and crew workload analyses should be performed and compared against the requirements.

Concurrence and Availability - Analyses of tasks should be modified as required to remain current with the design effort and should be available to the program manager.

Preliminary System and Subsystem Design - Human engineering principles and criteria are applied to system and subsystem designs represented by design criteria documents, performance specifications, drawings and data, such as functional flow diagrams, system and subsystem schematic block diagrams, inter-

face control drawings, overall layout drawings and related applicable drawings provided in compliance with program manager requirements. The preliminary system and subsystem configuration and arrangement should satisfy personnel-equipment/software performance requirements and comply with applicable criteria specified in ASTM F 1166 as well as other human engineering criteria specified by the contract.

Human Engineering Tools for Manning Reduction

The human engineering tools which facilitate the design process include: the Role-Of-Man determination tool, the task sequencing NETWORK tool, and the SIMWAM workload simulation tool. This paper discusses these below.

Role-Of-Man Determination Tool

A critical issue in the human engineering approach to manning reduction is establishing man's required role of in the system. Human engineers have developed and proposed a number of techniques to guide the system developer in using function allocation. Of these, most rely on Paul Fitts early concepts, in the form of a "Fitts list." This is a list of parameters which we operationally associate with implementing system functions. Examples include the amount of information required to perform a function, the extent of physical strength required, functional accuracy requirements, and system or mission tolerance to errors and/or delays in functional initiation.

For many functions, the required function allocation's nature is quite clear. For example, machines perform complex number manipulations much faster than humans; therefore, allocating such a function to a human would be foolhardy. Conversely, (for the time being) humans perform better those functions which rely on sensory and/or perceptual abilities. The objective is to develop the optimal man-machine functional allocation.

The Role of Man tool is an automated tool which assists engineers and developers in identifying alternate feasible roles of man in system operation and maintenance. Its operation consists of allocating functions to man, machine, or any combination of the two. The Role of Man tool then processes the information and recommends an allocation strategy and the optimum role of man in each system function. The Department of Defense developed the Role of Man tool and the tools described below.

Workload Simulation Tools

Human engineering workload simulations involve modeling of functional and task sequences for individual operators and maintainers and for crews. These models identify function and task sequences associated with alternate function allocation approaches. A tool appropriate for task modeling is NETWORK. This tool permits the analyst to graphically establish the relationships and dependencies among functions and tasks and supports the identification of the complete set of tasks. Further, NETWORK automatically builds a database for later automated input to the simulation model. In assessing the adequacy of alternate function allocation strategies of roles-of-man vs. automation, task sequences are modeled to reflect the distinguishing characteristics of each allocation approach. SIMWAM (Simulation for Workload Assessment and Modeling) then evaluates the allocation concepts. With SIMWAM, the developer can then determine and quantify the workloads and performance problems for each alternate allocation approach. This is possible for single and multiple operator systems.

SIMWAM is a task network simulation tool which can execute a network model previously defined by NETWORK. During a SIMWAM run, when a current task is completed, a subsequent task is brought out of the database (a " task call"). If sufficient operators are available for a task, then it will be started. Input data which describe a task include a list of qualified operators and the number of these required to perform the task. In attempting to start a task, SIMWAM will assign operators who are currently idle. SIMWAM can also attempt to interrupt lower priority tasks in process to obtain operators for higher priority tasks. Operators are not necessarily human operators but can be any resource entity including equipment.

When a task is ready to start, SIMWAM draws a random sample from the probability distribution of duration for the task. While the task is in process, operator time is accumulated on the task. When the task is completed, it can take other tasks from the database. If the call is <u>probabilistic</u>, then one task out of several will be taken from the database depending on specified probabilities. Human error, equipment failure, or a hit or miss following weapon firing are events which could be accommodated by probabilistic tasks calls. A task can also call one or more tasks <u>deterministically</u> when a fixed sequence of tasks exists. Task calls can also be made <u>conditional</u> on events or variable values by means of user-written subroutines. This capability ensures that virtually any logical condition for the start of a task can be accommodated. For example, tasks required to process objects in a queue could be taken from the database only if there is one or more object(s) in the queue. As SIMWAM executes a network model it tracks mission time, task completions, task start and end times, time spent per task per operator, and operator utilization. At the end of a simulated mission, these data can be compiled and printed. At the end of a simulation run involving a number of missions, the means and standard deviations of

mission data over the number of missions run can be compiled and printed.

SIMWAM is useful for addressing human engineering issues in system development since task duration parameters can reflect equipment changes or automation; operators can be added or deleted to study workload; and effects of cross-training and task re-allocation can be evaluated. SIMWAM can model complex man-machine systems with multiple operators who are able to swap tasks depending on system load. To date SIMWAM has been used to support analysis of operator-system performance in carrier launch and recovery operations, shipboard CIC contact processing, commander-gunner activities, and operation of tactical communications networks.

Human Engineering's Role in Ship Manning Reduction - a Case Study

In several attempts to reduce system manning, engineers and analysts have implemented the techniques and tools we have described above. NAVSEA conducted one such study which involved applying decision aiding techniques to status boards to reduce CV manning levels in aircraft management systems. This effort also resulted in the SIMWAM workload simulation tool's development. It assists in measuring human engineering's impact on design changes which affect system manning.

The CV aircraft management system includes 35 operators in the following areas:

- Carrier Controlled Approach (CCA) - 9 operators
- Air Ops - 7 operators
- Primary Flight Control (PRI-FLY) - 7 operators
- Launch Control - 2 operators
- Landing Signal Officer (LSO) platform - 4 operators
- Combat Information Center (CIC) - 6 operators

NAVSEA developed a scenario for exercise of this system which placed an emphasis on the variables affecting human performance, which included:

- type of operations (fleet exercise, simulated combat) with air strike mission;
- mix of aircraft - fighter, attack, EW, tanker, CAP, ASW fixed wing and helo, and COD;
- tempo of operations - launch/recovery rate of 25 aircraft in one flight operations cycle;
- wave off/bolter rate - 1 in 4;
- pilot skill levels - all carrier qualified;
- weather - good;
- visibility - visual flight rules;
- equipment status - all operable;
- manning levels - all relevant positions fully manned;
- number of replications - 12 launches, 13 recoveries.

We conducted a SIMWAM simulation for a scenario incorporating the above variables based on techniques currently implemented in the fleet. After we verified sequences and times to perform tasks by a ship visit to the USS CONSTELLATION, we completed the simulation for the baseline condition. We then adjusted the sequences inherent in the task network to reflect changes due to the introducing automated status boards (ASTABs) as decision-aiding devices. SIMWAM then completed a second simulation run with the ASTAB aids in place. Prior to conducting the second SIMWAM run with ASTAB's included, we analyzed the complete array of tasks all operators perform. This effort involved:

- determining which tasks would be affected by the addition of an ASTAB at the individual operator's workplace.
- determining which operators would have their jobs significantly affected by the use of an ASTAB that elimination of the position, or merger with another position, was warranted.

After we completed this gross task analysis, we made adjustments to the computer database. Of the 369 tasks in the study, 93 tasks (25%) in the first run would be affected by the availability of ASTABs. For those which involved ASTABs:

- The tasks which require an input function to the ASTAB would require a slightly longer time in comparison with previous task times.
- Those tasks involved in merely relaying information could be eliminated, since the information would already be in the system and available to any operator with access to an ASTAB.
- Those tasks involved purely in retrieval remain unchanged. (While the time to retrieve the information is assumed to be the same, whether it is displayed on a plastic status board or ASTAB, there may be a small gain in time due to the uniform reliability of an automated system. This factor was not included in the adjustments made.)

Applying improved human engineering technology by using the automated status board had several significant impacts on CV aircraft management system operations. These were as follows:

1) a reduction of 4 billets, resulting in a reduction in manning level of 11%

2) an average reduction of overall time to perform the aircraft launch and recovery sequence of 20%
3) a reduction in time to perform aircraft management tasks of 25 of the 31 operators
4) a reduction of the number of operators who were heavily loaded by 50%

Summary and Conclusion

The role human engineering plays in reducing ship manning levels is becoming increasingly important as the applicant pool for military personnel decreases. Past efforts to alleviate the human operator's workload have focused on allocating portions of his work to hardware or software. The human engineering approach to the problem stresses identifying the human's role regardless of the extent of system automation. Through establishing the operator's position and responsibilities, the designer can develop a cost effective system that optimizes human and machine capabilities. A second important consideration is the balance between workload and manning. Engineers should base manning requirements on the tasks humans perform. Careful analysis of the operator's tasks will indicate where and if physical and/or mental overload occurs. Researchers, developers, and engineers can then develop automation that reduces the load on the human operator.

This paper has suggested several human engineering techniques for reducing manning. These include applying design principles and standards, simplifying tasks/jobs, and developing decision and performance aids. By using human engineering tools, we can achieve these three steps which carry out the objective of integrating humans, hardware and software into optimum man-machine systems. Human engineers in the industry have created several tools which facilitate task delineation and allocation between man and machine. One of the most useful tools is SIMWAM because it acts as a "rapid-prototype" for automation. We can trade off automatable tasks against human performance and compare the approaches in terms of time and manpower.

The example clearly indicates that applying human engineering analysis to a scenario involving machinery and personnel and automating tasks and providing operators with decision aids reduces ship manning. The case study indicated that automation and decision aiding resulted in an 11% reduction in CV manning levels for this workstation.

This approach to the next generation's military systems will ensure that system operations will address the role of man. It will also ensure that we base smart manning reduction efforts on the results of human engineering analysis and produce more affordable weapon systems. They are those systems that adequately meet mission requirements and operate in scenarios where human and machine components work together efficiently, effectively, and productively.

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__David E. Anderson__ was born in St. Lucie County, Florida in 1954. He has a Bachelor of Science degree in Environmental Engineering from Florida Technological University and a Master's in Environmental Engineering from the University of Central Florida. He is a graduate of the Naval Sea Systems Command (NAVSEA) Command's Engineer-In-Training (EIT) program.

Mr. Anderson was instrumental in introducing the Collective Protection system (CPS) in the U.S. Navy, developing the initial forward-fit package for the USS Gunston Hall and the Engineering Change Proposal (ECP) for the USS Wasp. In 1990, he joined the Human Systems Integration (HSI) Division (SEA 55W5) where he was Task Leader for Auxiliary Ships. Today he is an

HSI manager for the Future Technology Variant of the SeaLift Ship and the Future Carrier.

<u>Clifford C. Baker</u>, M.A., CHFEP. Mr. Clifford C. Baker is a Senior Staff Scientist at Carlow with over 20 years of experience in the application of human engineering technology to military, space, transportation, commercial, and military systems. Since joining Carlow, Mr. Baker has directed much of the Corporation's efforts to reduce ship manning and improve human performance and safety through human factors methods and data. He has been involved in numerous human-computer interface design, test, evaluation, and experimental efforts. He rewrote DOD-HDBK-761, the Department of Defense handbook of human engineering guidelines for human-computer interface design. Mr. Baker worked for two years as a Personnel Research Psychologist for the Navy Personnel Research and Development Center, the Navy R & D laboratory responsible for personnel and human engineering related research. Mr. Baker was involved in the displays design for several Naval anti-air weapons systems. Prior to his Navy work, he served as Head, Human Factors Analysis and Technology Branch of the Commercial Systems Division of the Essex Corporation. Mr. Baker has extensive experience in the application of psychophysical measurement techniques as they relate to equipment design and evaluation. Mr. Baker also has extensive experience in the development and application of surveys and interview methods. He has authored or co-authored over 40 published technical articles or reports and has participated in the authoring of four books. Mr. Baker has also participated in the writing and/or revision of numerous military human engineering standards and specifications.

<u>Thomas B. Malone</u>, Ph.D. CHFEP. Thomas B. Malone received a Ph.D. in Experimental Psychology from Fordham University in 1964. He is President of Carlow International Incorporated, an organization dedicated to human factors research and development with emphasis on maritime systems. He has directed over 350 programs and projects in his 33 year career and is responsible for overall management of all contract programs within the Corporation. He is a Past President of the Human Factors and Ergonomics Society (HFES), of which he is a Fellow. He is also a Fellow of the Washington Academy of Sciences. He was awarded the HFES 1989 Alexander C. Williams award for outstanding contribution to the design of a major operational system. He was selected as a member of the NASA Space Sciences Technical Advisory Committee on Technology Requirements for Human Performance on Long Duration Space Missions in 1989 and 1990. He was elected as the First Chair of the Systems Development Technical Group of the HFES.

<u>Fred R. Oberman</u>. Mr. Oberman has B.A. and M.A. Degrees from the University of Chicago (Psychology-Social Science) and Loyola University (Experimental Psychology) and a M.S. Degree in Industrial Engineering and Operations Research from Virginia Tech (VPI). He has over 30 years experience in HSI management, planning, research, analysis, design and testing in government and private sector positions as applied to Aerospace, Ship, Electronic, Health Care, Transportation and Business Systems. He is currently responsible for NAVSEA Human Systems Integration (HSI) efforts on the CVX program and on current attack submarines (SSN-21), is responsible for HSI Generic Research and Tool Development efforts and is also responsible for Generic Human Engineering. He is responsible for Human Engineering Specifications and Standards (Commercial, Hypertext) and is the NAVSEA 03D7 representative on HSI in Performance Specifications. and for integration of HSI within ILS. He has served as Committee Chair and Board Member of local HFS chapters, DoD HSI SubTAG Chair and member of the Simulation and Modeling, Test and Evaluation, Display and Control Systems, Human Computer Interaction, Specifications and Standards, and Systems Design SubTags, as a member of the SNAME Systems Safety Panel and a member of NATO RSG 14 on Man-Machine Analysis. He is currently the NAVSEA representative to the HSI Policy group formed per the direction of ASN (RD&A) and awaiting appointment as co-chair of the DoD Modeling and Simulation SubTAG.

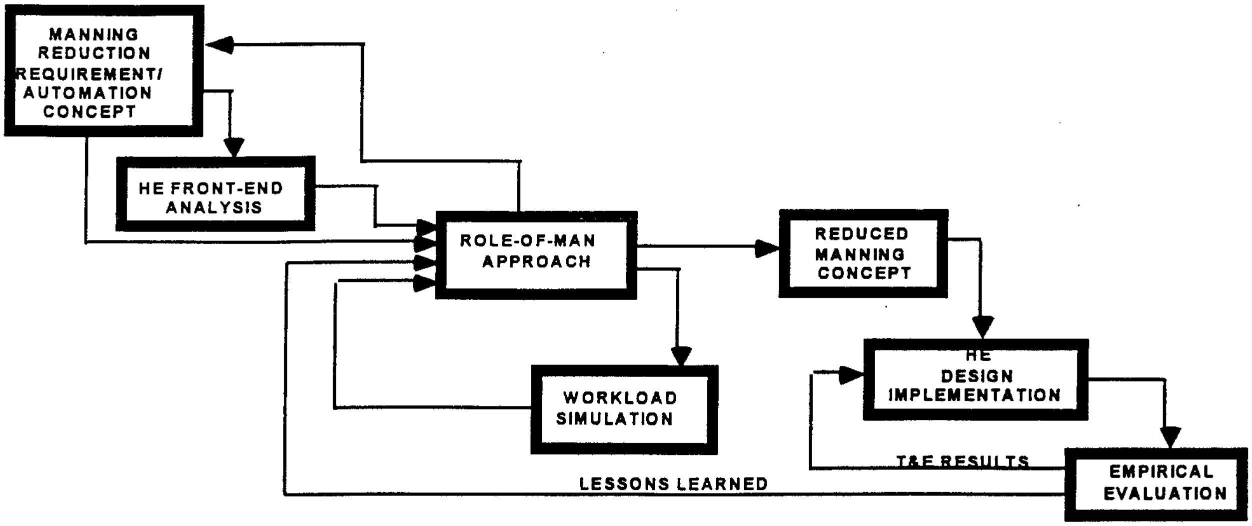

Figure 1. Human Engineering Approach to Ship Manning Reduction

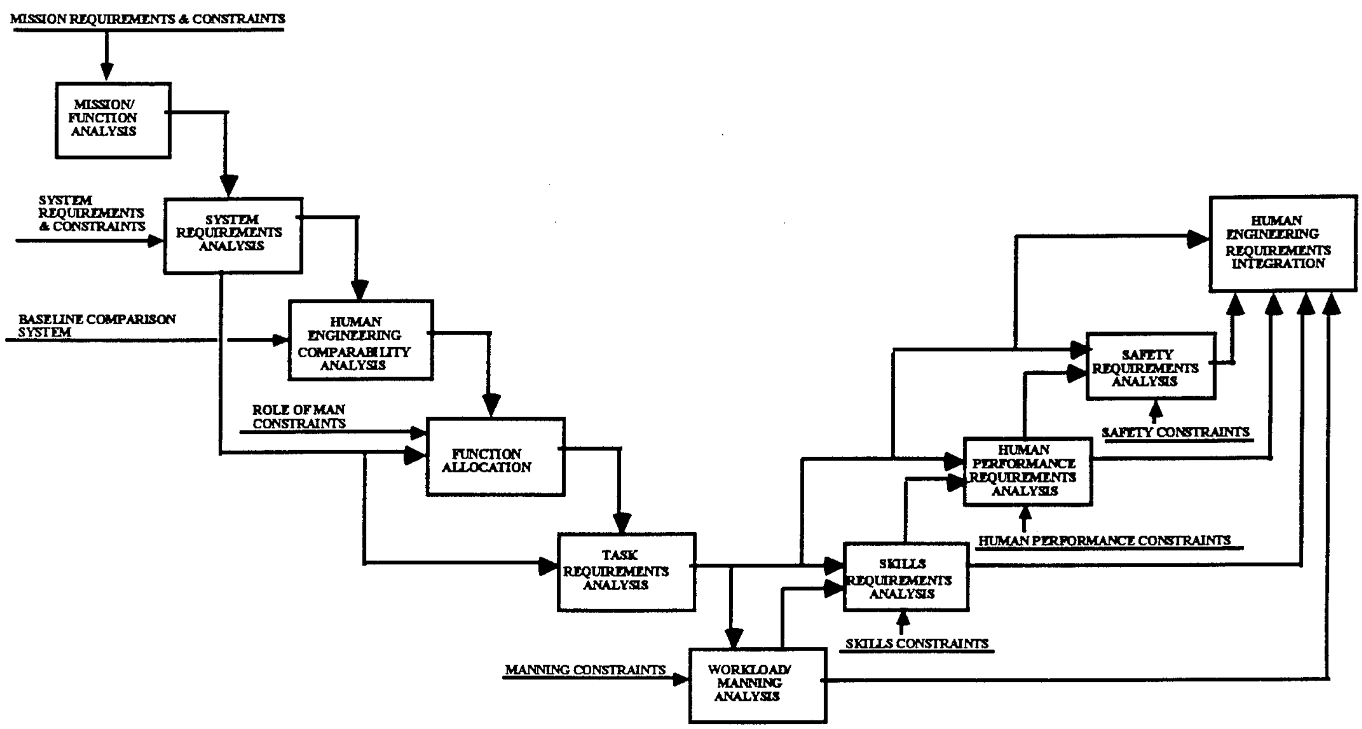

FIGURE 2. HUMAN ENGINEERING FRONT-END ANALYSIS

SHIP HABITABILITY - PREPARING FOR THE 21ST CENTURY

Edward P. Meere
Habitability Program Manager
Arrangements Division
(Code 03H1H)
Naval Sea Systems Command

Louis Grieco
Habitability Branch Head
(Code 9790)
Naval Surface Warfare Center, Carderock Division
Ship Systems Engineering Station, Philadelphia

The views expressed herein are the personal opinions of the authors and are not necessarily the official views of the Department of Defense or the Naval Sea Systems Command

Abstract

This paper discusses the problems identified in a FY 1995 fleet habitability survey. The survey questioned the fleet on the quality of shipboard living and working conditions and identified shortfalls in berthing, sanitary spaces, and food service systems that influence crew morale, safety, and ultimately mission effectiveness. Existing habitability programs, new initiatives and responses to the survey problems - plus a few quality of life ideas for the 21st century are outlined.

List of Figures/Tables

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Notations/Definitions/Abbreviations

ASE	Association of Scientists and Engineers
ASNE	American Society of Naval Engineers
ATC	Affordability Through Commonality
BUSHIPS	Bureau of Ships
CD-ROM	Compact Disc - Read Only Memory
DART	Development And Response Technique
EQOL	Enhanced Quality Of Life
FTSC	Fleet Technical Support Center,
ILS	Integrated Logistics Support
INSURV	Board of Inspection and Survey
ISEA	In Service Engineering Agent
LCM	Life Cycle Manager
LWMB	Light Weight Modular Berth
NATO	North Atlantic Treaty Organization
NAVSEA	Naval Sea Systems Command
NAVSUP	Naval Supply Systems Command
NEXCOM	Navy Exchange Command
NOB	Naval Operating Base
NSWCCD-SESS	Naval Surface Warfare Center Carderock Division, Ship Systems Engineering Station
OPNAV	Operations Navy
POM	Program Objective Memo
TYCOM	Type Commander
WAS	Women At Sea

Introduction

There is little doubt that the United States Navy is the best fighting force in the world, having the latest weapon and detection systems, state of-the-art technology, the fastest ships, and the best trained sailors. This superiority, however, does not extend to shipboard habitability.

Habitability is about living and work spaces, the spaces service men and women occupy on the job and in their off hours. The changing face of a peace time Navy dictates a new outlook on the living and working environment provided for officers, CPO and crew. Ships are small floating cities and the dynamics created by crowded, noisy, poorly ventilated and

equipped living spaces adversely affect productivity, cost effectiveness, and ultimately, readiness. This paper is about the human element issues that affect crew readiness and mission effectiveness, about making living spaces better, life better, for men and women serving aboard U.S. Navy ships. This paper is about realizing ship habitability shortfalls, correcting them, and improving the habitability standards.

In order to determine the habitability issues most pressing to the fleet a habitability survey was taken by the people most affected, the sailors who live and work at sea. The first half of the paper reports issues solicited from the survey and some related on-going habitability projects. The second half deals with new habitability initiatives and the quality of life for sailors and the mission effectiveness of ships, and closes with some habitability ideas for the 21st century.

Background

Habitability aboard U.S. Navy ships evolved from a very meager beginning. Just over 40 years ago it was common to find U.S. Navy ships with four, five, and six high berths (Figure 1), sanitary spaces with no partitions between toilets (Figure 2), berthing areas doubling as messrooms, 50 sailors for one shower, hot stuffy berthing spaces located next to power plants, and no air conditioning anywhere. Before the mid-50's habitability standards were non-existent. Ship designers and builders designed the living spaces after all the major ship systems were defined. The first attempt at a shipboard habitability instruction was at the BUSHIPS 'Habitability Indoctrination Seminar' in March 1954, three years after shipboard habitability was made a military characteristic. The first instruction for shipboard habitability was not published until 1960. [1] This instruction has been updated twice since then, however, only a few of the original requirements have been updated.[2] These requirements dictate the living standards for sailors on all ships, including those under design. Most shipboard habitability improvements evolved through new ship designs without the assistance of current standards. In spite of the slow evolution of habitability standards and after-the-fact design considerations, designers, naval architects, and users have made some remarkable contributions to the quality of life aboard ship.

In the 1970s, under the leadership of CNO Admiral Zunwalt, shipboard habitability experienced new zest and many of the ships in service today are realizing a more habitable environment because of his interest. This new interest provided the opportunity for ship designers, naval architects, and users to make some lasting contributions to the quality of life aboard ship in spite of the slow evolution of habitability standards. Several examples will be mentioned.

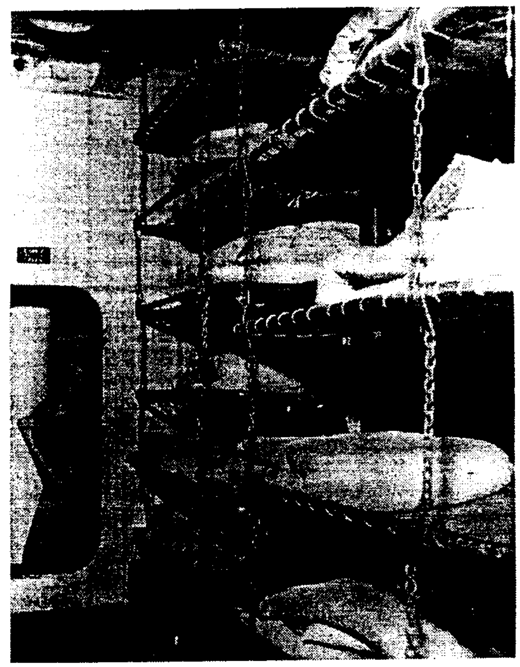

Figure 1
Five and Six High Berths

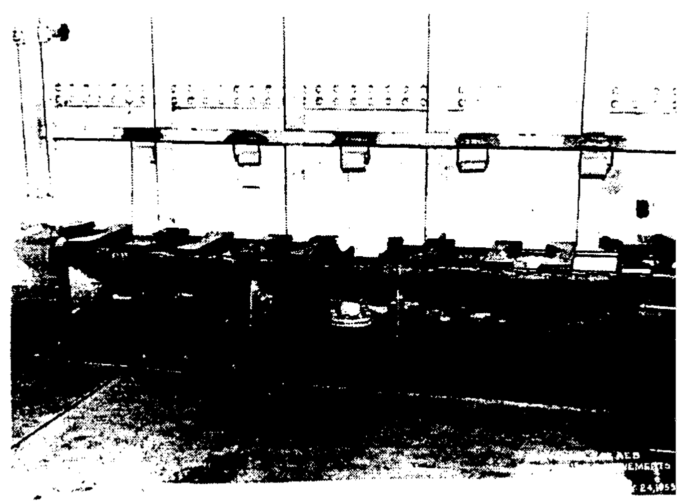

Figure 2
Unpartitioned Sanitary Space

Fleet Habitability Issues

In December 1994 NSWCCD-SSES by message requested the TYCOMs to survey ships under their command for shipboard habitability issues and problems. The response was exceptional, with input from 28 commands and 62 ships. The issues received were assessed and classified into nine categories: berthing, sanitary facilities, foodservice systems, personal services, laundry, offices, lounges, uniforms, and furniture.[3] The first three issues, berthing, sanitary, and food service, comprise over 60 percent of the responses received in the survey and will be the only fleet issues discussed. (Table 1)

Table 1
Top three Habitability Issues and Elements

ISSUE	ELEMENTS
Berthing	Berth Area Personal Stowages Berth Design Amenities Troop Berthing Sleeping Gear Program Support
Sanitary Facilities	Space Fixture Variety Fixture Performance Flushing Piping System Fixture Quality Program Support
Food Service	Configuration Equipment Performance Support Space Menu

Berthing

The issue of greatest concern to the fleet is the berthing compartment. They complained that these spaces are crowded and impersonal, too noisy, too large, cluttered with personal gear, and inadequate stowage. The lack of boot stowage and the need for a place to dry wet towels and exercise clothing were chronic objections. They mentioned noisy recreation areas located in the middle of sleeping compartments, berthing areas bisected by high traffic passages, and Sanitary Spaces remote from the berthing space. They also asked for electrical receptacles in the berths for radios and CD players. (Batteries for these items add to the ship's hazardous waste and are an expense to the sailors.) Troop berthing areas, especially on older ships, were identified as deplorable.

Sanitary Facilities

In the survey responses none were received indicating any problems with sanitary spaces assigned to officers. CPO and Crew sanitary spaces however, were a different matter. The survey revealed the crew's dislike of the way the bathrooms were arranged for traffic flow. They felt they were poorly ventilated, damp, lacked privacy, and were difficult to clean. They also complained of poor parts support, piping systems that clog and back up, and fixtures that easily break or corrode. The inadequate ratio of sanitary fixtures to crew berths is a major problem. According to a cursory survey by the authors, the U.S. Navy has the highest(worst) ratios for the number of crew/troop per fixture (shower, toilet, sink) of the six following navies: The Royal Dutch Navy, NATO, The French Navy, The British Navy, The German Navy and The Royal Norwegian Navy.

Food Service

The survey cited comments concerning messrooms, galleys, food stowage spaces, sculleries, and bakeries. The majority of complaints referred to unreliable galley equipment, poor arrangement of the mess area, long mess lines particularly during lunch and dinner, and opposing traffic flow. Survey comments stated that galley equipment was located to fit the space rather than arranged in an expedient functional sequence. Obsolete equipment and variations of equipment for the same function were a repeated complaints. Downtime of unreliable equipment and nuisance failures make the galley a stressful workplace. Long hours in a hot stuffy precarious work environment lead to fatigue and accidents. Steam equipment was, for the most part, unpopular. Lack of parts support, proper maintenance, and technical and operational manuals are nagging concerns for galley personnel. They also thought that more outside commercial support would help resolve maintenance and operational problems. More varied and healthy foods and menus were also requested.

Current Habitability Initiatives

The issues identified in the habitability survey provide the habitability program manager, TYCOMs, and other Commands with the necessary data for planning future habitability updates and modifications. The Navy has several programs that deal with habitability issues. The following, while not a complete list, outlines some of the principal programs relating to the survey.

Self Help

The Self Help program is a TYCOM supported Fleet Technical Support Center (FTSC) managed NAVSEA program dedicated to improving enlisted living spaces. Self Help uses ship personnel to upgrade berthing and sanitary spaces by removing and replacing outdated and broken berths, lockers, and sanitary fixtures, installing new deck coverings, and improving the general appearance of these spaces. Self Help completes about 225 berthing compartments and 100 sanitary spaces on 65 ships in a given year. Since 1975 Self Help has installed 140,000 berths and upgraded 1400 sanitary spaces.

Enhanced Quality of Life (EQOL) Program

This program, funded by COMNAVAIRLANT and COMNAVAIRPAC, provides operational and maintenance training to personnel working on the food service, laundry, and dry cleaning equipment on aircraft carriers. It also repairs and replaces faulty equipment. Other TYCOMs are starting similar programs with technical assistance from NSWCCD-SSES.

Affordability Through Commonality (ATC)

The biggest benefactor to advancing the state-of-the-art of shipboard habitability systems over the past few years has been NAVSEA's ATC program. ATC was established to find ways for the Navy to reduce the cost of ownership through equipment and systems commonality. This program is supporting projects to develop: innovative food service equipment and systems, standard commercial marine shipboard furniture, modules for berthing and sanitary spaces (Figure 3), office workspaces, stowage aids, medical and dental complexes, and a new berth design (Figure 4). All of these projects must take into account the resolution of fleet habitability issues.

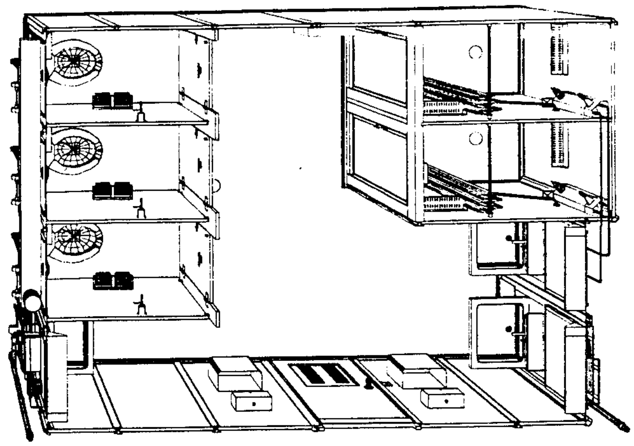

Figure 3
ATC Crew Sanitary Space Module

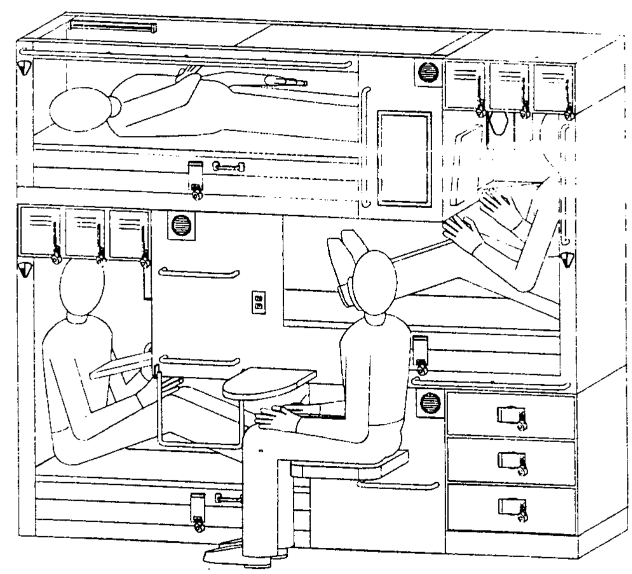

Figure 4
New Berth Design

Submarine Habitability

Submarine habitability issues are some of the unique and chronic problems of the Navy's habitability. Improvements in habitability are made through new ship design studies. Through OP 87 funding, NAVSEA is working on hot bunking, furniture standardization, and food preparation systems.

Women at Sea

With the repeal of the Combat Exclusion Law in 1993, women are serving on all ship types in the same capacity as their male counterparts. To assure privacy for both men and women modifications had to be made to berthing compartments, sanitary facilities, deck washrooms and water closets, and medical facilities. Furthermore, unrestricted access to storerooms and work stations were provided to both men and women. Above all, these changes had to be accomplished at minimal cost and disruption to the ship. With these changes came quality of life improvements for both men and women such as: smaller sanitary and berthing spaces, bulkheads separating berthing spaces from general ship access, and sanitary spaces immediately adjacent to berthing. Integrating women into ship living and working spaces is far from complete, but what has been accomplished is a credit to our naval architects and designers. To date 33 combatant ships have been modified to accommodate approximately 4600 women sailors of all ranks.

New Ship Designs

New designs provide additional opportunities, the manpower and funding to improve shipboard systems. Time and funding constraints usually limit the extent and number of design improvements, however, many of the improvements in shipboard living have evolved through new ship designs. The LPD 17, for example has smaller crew, troop, and CPO berthing spaces than the LHD. The six person CPO bunkrooms come with an attached sanitary space. All the sanitary spaces are modular ATC designs equipped with modern fixtures utilizing space more effectively. Efficiencies in food service were also realized by combining crew and CPO galleys. All the crew berthing spaces contain dedicated recreation areas. These are typical quality of life improvements developed through new ship designs. Habitability improvements such as these can be short-lived when faced with system tradeoffs and new technology weapons.

Life Cycle Management NSWCCD-SSES

None of the above programs could be executed effectively without the life cycle managers (LCM) and in-service engineering agents (ISEA). The LCM and ISEA of habitability equipment is accomplished through the efforts of the Habitability Branch at NSWCCD-SSES, Philadelphia, Pa. As the equipment managers they review and approve all requests for deviations to standard equipment purchases. They are responsible for the maintenance and updating of over 700 specifications, drawings, and standards for the 1100 plus habitability equipment and furniture items. They are also responsible for developing and updating the habitability catalogs, (Shipboard Laundry and Dry Cleaning Equipment Catalog, Naval Shipboard Food Service Equipment Catalog, U.S. Navy Shipboard Furniture Catalog, and Handbook of Shipboard Facilities Maintenance) and providing technical assistance and approvals to the fleet acquisition managers and ship design engineers. [4] [5] [6] [7]

New Initiatives

Programs like ATC, Self Help, EQOL, and new ship design improvements will, in time, relieve many of the problems identified in the fleet habitability survey, but not for all ships or all problems. New ship designs will reap the fruits of the ATC efforts. On existing ships EQOL, Self Help, and the habitability life cycle managers will continue to maintain and correct many of the habitability issues on existing ships. However, unless significant measures are initiated and funded, experience has shown that the quality of life for the majority of the men and women serving aboard ships will be slow to improve. Self Help improvements take four to six years from ship selection to completed installation. Most ATC efforts are two or more years from approval and some won't happen until new construction.

Documentation

The most pressing issue is to continually update the standards, criteria, and practices of habitability documentation such as: OPNAVINST 9640, the Shipboard Habitability Design Practices Manual[8], and the habitability catalogs. OPNAVINST 9640 contains the design standards for shipboard habitability systems. (INSURV uses this instruction as the standard for their inspections). Some of the design parameters and metrics are outdated, restrictive, and do not reflect contemporary culture and emerging technologies limiting habitability designers from upgrading living and work spaces. It needs to include guidelines on the maximum number of personnel in a berthing space, reflect more specifics

on lounge and recreation compartments, and include validated ratios on the number of personnel per sanitary fixture. The Habitability Design Practices Manual is based on information taken from out of date standards and does not include state-of-the-art habitability concepts. The habitability catalogs need to be updated regularly and widely circulated to be of use to the fleet, and the overwhelming majority of nearly 700 specifications and drawings have not been updated or purged in years.

Habitability Master Plan

With the many disjointed and sometimes redundant efforts being undertaken through the Navy to improve shipboard habitability a consolidated program plan is essential. This plan will prioritize all Navy projects against time and funding with a strategic outline establishing POM issues for the respective OPNAV Platforms. It would describe the 'what and when' of all habitability efforts and programs throughout the Navy. It would layout NAVSUP projects and programs in food service and stowage aids, TYCOM plans for Self Help and EQOL, Women at Sea projects, habitability ship alterations, Fleet initiatives, Research and Development projects, and NAVSEA programs. It would be a multi-year planning document showing everything that is being done and planned for shipboard habitability. Funding has been allocated to start this effort, but is only a small fraction of that necessary to execute such an undertaking.

Berthing Compartments and Berths

Of all the issues and ideas discussed in this paper, the survey showed berthing compartments to have the greatest single impact on crew morale. Imagine having 100, 200, even 235 roommates. Those numbers can be found on the CVN's, LHA's, and LHD's. On the CVN 68 Class there are five berthing compartments each with over 190 berths, too large a space to be kept quiet and orderly or for bunkroom mates to get to know each other. One of the reasons given for theft aboard ship is the impersonal nature of the large berthing areas. A crewman on one of the ships visited claimed that thievery did not exist on his ship - a destroyer with less than 20 people per berthing compartment. How big should berthing compartments be? Some European navies have attempted to answer this question. The Royal Dutch Navy[9] suggest a maximum of 12 seamen per berthing area, the French[10], British[11] and NATO[12] Navies recommend a ceiling of 24 seamen per compartment. the Royal Norwegian Navy[13] calls for a maximum o 6 seamen per cabin, and the German Navy[14] recommends 4, 6 or 8 person living spaces. These navies are on the right track with smaller berthing areas. The argument that the deck space used for habitability improvements compromises the space for high priority ship systems is unfounded and counterproductive. It has been demonstrated repeatedly that crew morale enhances the mission effectiveness.

A discussion on berthing would not be complete without attention to crew berths. The Lightweight Modular Berth now in use allows a sailor only 18-20 inches of clearance between racks, not enough room t sit up, read comfortably, or even turn over without difficulty. NAVSEA has developed a new berth (Figure 4) that permits the occupant to sit upright, providing a quiet space to read, relax or listen to music. A mockup of this berth was presented at the ASNE Fleet Maintenance Symposium in Virginia Beach, Va. this past November and at the carrier piers at NOB Norfolk. The reaction was overwhelmingly positive. The comments most often heard were "When are we going to get that?" or "Would you please put that in compartment ###". This berth gives the sailor 50 percent more folding and hanging stowage, a recurring complaint from the habitability survey. It provides boot stowage and has a fold down seat and ironing board. It also comes with a 4 inch inner spring mattress. There is one drawback- it is 19 inches longer than the existing berth and backfitting may present a problem. The few ships studied indicate some encroachment into the lounge areas. We plan to look at all ship classes as the berth becomes more of a reality. Funding through the ATC program got us to the mock-up stage in development and there are signs that funding will continue for design and prototype development.

Habitability for the 21st Century

The U.S. Navy has the resources to improve the quality of life for our sailors as we head into the next century. Navy goals are common with the other Services: better retention rates, cost effective equipment, improved morale and work habits, SMART ships, and improved readiness. For ship habitability systems there remains plenty to be done.

A general shopping list for 21st century ships should include:

- An understanding that the sailor's berth is his/her home(a quote from NAVSEA's Command Master Chief). The 18 to 20 inches between bunks currently specified is unsatisfactory, the space should be sufficient for leisure as well as sleeping.
- Berthing compartments should be kept to a maximum of 24 seamen.
- Personal stowage should be increased to accommodate uniforms, work and civilian clothes, boots, personal items: radios, CD players, hobby equipment, and miscellaneous items.
- Each berthing compartment should have a small towel drying area similar to what other navies provide.
- Easy to clean and maintain sanitary facilities with validated personnel to fixture ratios.
- Habitability standards equal for both crew and troops.
- An entertainment system that allows for educational material that can lead to a college degree- available on all ships.
- An adequate exercise or sports room.
- Peace and wartime work and deployment scenarios should be considered separately. Physical hardships are acceptable in combat situations, but in peacetime other factors should be emphasized.

Conclusion

Improvements in shipboard quality of life systems heighten morale, decrease crime and social conflicts, and foster better work habits. As job satisfaction increases so does mission effectiveness and retention of quality sailors. Ships of the next century will have more automation, smarter systems and fewer sailors. We will need to recruit and retain the best people for these jobs. Improving ship habitability systems can help make that happen. Smart sailors make SMART ships.

Acknowledgments

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Biographies

***Edward P. Meere** works in the Arrangements Division of the NAVSEA Systems Command (SEA 03H1) and has been the Navy Habitability Program Manager for the past three years. He received a Bachelor of Science in Engineering Science from Illinois Institute of Technology in 1966. He received a Masters of Business Administration from the American University in 1977. His experience to date includes: Mathematics teacher at Prince Georges Community College for 7 years; 10 years as Branch Head for Carrier and Amphibious Arrangements; Project Engineer for Underway Replenishment Equipment, responsible for the concept and development of the One Man Control Station. He recently wrote an article on Shipboard Habitability for NAVSEA'S Deckplate magazine and is organizing a Shipboard Habitability Conference for May '96.*

***Louis R. Grieco** is a Supervisory Mechanical Engineer in the Habitability Branch of the Hull and Deck Machinery Department at the Naval Surface Warfare Center, Carderock Division, Philadelphia where he has been employed since 1971. He received a Bachelor of Science in Mechanical Engineering degree from Drexel University in 1979. His experience to date includes: trade, design, and combat systems assignments at Philadelphia Naval Shipyard from 1960 to 1971; In Service Engineering Section and Branch Head for cargo/weapons elevators, conveyors, torpedo handling systems, habitability equipment, and underway replenishment equipment through the end of Fiscal year 95, and as Life Cycle Manager for habitability systems since 1 October 1995. He also serves as a member of the Industrial Advisory Board at Temple University, Philadelphia, PA.*

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3D Visualization Applied to Electromagnetic Engineering

CDR Steven Z. Elbinger
Ramses Routier
Combat Systems Topside Design (NAVSEA 03K24)
Naval Sea Systems Command

Approved for Public Release
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Abstract

Over the past few years, the NAVSEA Topside Design Group has conducted extensive development of the electromagnetics code for Naval Ship Topside design. Analysis of computational electromagnetic data has long been a challenging task for surface ship designers.
There are a number of very good computational models for analyzing a surface ships' electromagnetic characteristics. Unfortunately, the output of these models consist of huge matrices of real numbers that are very difficult to analyze.

This paper will show how NAVSEA, in conjunction with NCCOSC/NRaD and Rockwell International, is using computer graphics to help Surface Ship Topside Designers optimize the Electromagnetic characteristics of a ship's design. NAVSEA has developed 2D & 3D scientific data visualization tools that provide an intuitive "feel" for the output of the numeric computational electromagnetic models.

This paper will also describe how industrial software standards and fast, inexpensive graphics engines will provide Electromagnetic Design engineers with much more capable, robust, flexible, portable, and economical scientific visualization tools.

List of Figures:

EDGEWISE ORIENTATION OF THE SPS-48E ANTENNA.

FIGURE 19: UNBLOCKED AND BLOCKED ELEVATION PATTERNS FOR THE CEC ANTENNA FOR EDGEWISE ORIENTATION OF THE SPS-48E ANTENNA.

Notations/Definitions/Abbreviations

BSC	Basic Scattering Code
CAD	Computer Aided Design
CEC	Cooperative Engagement Capability
COEDS	Co-site Engineering Design System
ECM	Electronic Counter Measures
EM	Electromagnetic
EMC	Electromagnetic Compatibility
EMENG	Electromagnetic Engineering
EMI	Electromagnetic Interference
GL	Silicon Graphics' Graphics Language
HERO	Hazardous Electromagnetic Radiation for Ordinance
HERP	Hazardous Electromagnetic Radiation for Personnel
HF	High Frequency
HPC	High-performance computing
JTUAV	Joint Tactical Unmanned Aerial Vehicle
MOTIF	High level X11 software library
NAVSEA	Naval Sea Systems Command
NCCOSC / RTD&E	Naval Command, Control and Ocean Surveillance Center, RTD&E Division
NEC	Numerical Electromagnetic Code
NEEDS	Numerical Electromagnetic Engineering Design System
NRaD	NCCOSC/RTD&E
OpenGL	SGI's Graphics Language that runs on all major computers
SGI	Silicon Graphics, Inc
X11	Open, standard, computer windowing environment
XGraphics	Rockwell Intl's Graphics Language

Introduction: The Electromagnetic Environment on US Naval Vessels

Because of limited real-estate, Navy ships have high power radar and satellite communication antennas placed in close proximity. To resolve shipboard systems degradation caused by electromagnetic interference, the NAVSEA Topside Design branch has developed several electromagnetic engineering tools to handle the ship topside challenge. These tools simulate electromagnetic environmental effects in which shipboard equipment are exposed. The tools allow users to model a specific ship hull scenario (platform, structure, railing, and equipment) to assess where equipment should be placed without jeopardizing performance. This paper demonstrates how 3D visualization techniques enhance our ability to see, interpret, and represent electromagnetic interference problems caused by both friendly and hostile systems.

"Friendly systems" can be described as systems that operate nearby at the same frequency band. "Hostile systems", also known as Electronic Countermeasure (ECM) systems, attempt to deceive or desensitize the system being targeted. For example, Chaff which is used primarily as a defensive deceptive measure, can desensitize sensors and weapon systems. Decoys radiate energy signatures matching those of particular systems to draw attention away from other systems. They can be used to confuse sensors and weapon systems, both offensively or defensively.

In order to reduce effects of electromagnetic interference, a set of software tools have evolved. These tools will be described in this paper as follows:

A. An overall description of the EMENG Workstation Architecture.

B. Purpose and description of the NEEDS/NEC models.

C. Purpose and description of the Ray Tracing and Casting model, 2D plot of predicted energy received by shipboard antenna graphical interface, and the 3D deck house with the EM rays displaying multiple reflections.

D. Purpose and description of the GMULT/GCOUPL model, and 2D near-field antenna pattern.

EMENG Workstation Architecture

The EMENG Workstation is a set of software tools that enable the user to analyze the electromagnetic signature of a surface ship. The major components are electromagnetic modeling, CAD databases, EM databases, and the graphical user interface (see figure 1).

EM Geometry Processing: Converts IGES CAD files into specialized EM formats.

Computer Hardware: The EMENG Workstation runs on Digital Equipment Corporation's VAX/VMS, InterGraph/CLIX[2], and Silicon Graphics workstations. Graphics coprocessors are recommended, but not required.

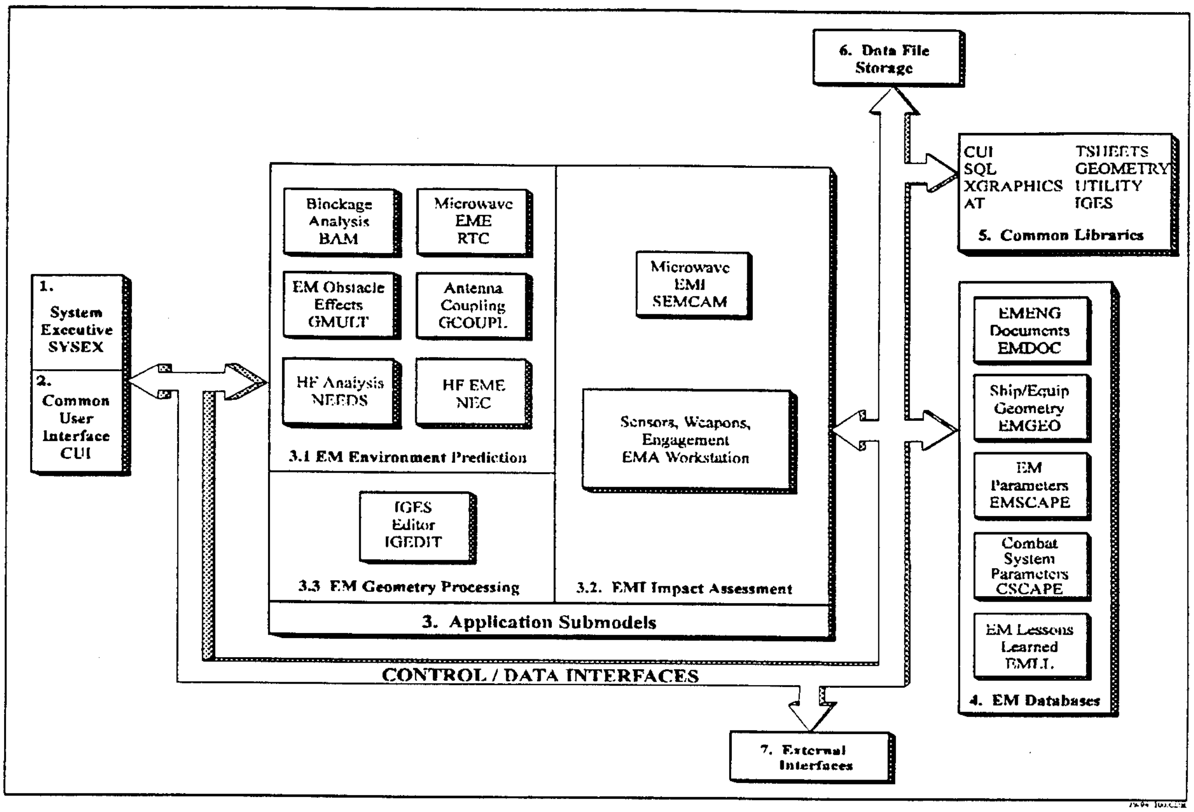

Figure 1: EMENG System

Application Submodels:[1] The EM modeling tools are divided into three groups:

EM Environment Prediction: These tools predict ship EM environment based on equipment characteristics and ship geometry.

EMI Impact Assessment: These tools analyze the effects of the EM Environment on ship and system performance.

EM Databases: The primary databases; EMGEO, holding geometry definitions; and EMSCAPE, holding electromagnetic parameter definitions; use SQL/Informix as the database engine.

Languages: The EMENG Workstation is written in FORTRAN and ANSI C.

Graphical User Interface: X11/Motif was chosen as the user interface to allow portability

to a wide variety of computer platforms. Athena Widgets and widgets developed by Rockwell International provide a "common look and feel."

Graphics: Two different graphics libraries are used: XGraphics and GL. XGraphics is a graphics library written by Rockwell International. The goals of XGraphics are to provide inexpensive portability to any X11-based operating system and to provide a shell layer between EMENG applications and the actual graphics library. If a new graphics library is chosen (such as OpenGL), XGraphics can make calls to the new library thus avoiding rewriting all EMENG modules.

Silicon Graphics' proprietary graphics library GL is used on EM applications running on SGI computers.

NEC

Computer modeling has become a powerful and widely used tool for the design of antennas. Under the NAVSEA Electromagnetic Engineering (EMENG) program, several computer tools have been adapted for designing the exterior RF communication, Electronic Warfare (EW), and radar systems for Navy ships. The two principal computer design aids are the Numerical Electromagnetic Engineering Design System (NEEDS) and the Co-site Engineering Design System (COEDS). The NEEDS workstations supports the topside designer in determining the antenna performance. The COEDS workstation supports the topside designer in the Electromagnetic Compatibility (EMC) analysis of the communication, EW, and radar systems in the co-site environment. Antenna performance and coupling data obtained from NEEDS-MoM and NEEDS-BSC are used as input to the COEDS workstation.

Today, Topside Design uses the Navy Shipboard exterior RF system design approach for electromagnetic compatibility assessment work. Given a proposed design in a RF system diagram, a topside designer sets requirements on the coupling or isolation between transmit and receive or transmit and transmit antennas. The required antenna isolation is used to make the undesired power less than the maximum tolerable level for specified receiver performance. By comparing the required antenna isolation with the achieved antenna isolation, the topside designer determines whether additional isolation between transmit and receive antenna is necessary to obtain an electromagnetically compatible system.

The *Numerical Electromagnetic Code - Method of Moments* (NEC-MoM)[3] is used to model antennas at UHF frequencies and below. NEC-MoM solves the electromagnetic problem using an integral equation technique. For NEC-MoM the ship is modeled as a wireframe which is created and visualized with the NEEDS-MoM workstation. The lengths of the wire segments are dependent on the frequency of interest. The higher the frequency the shorter the wire segments. For antenna frequencies at UHF and above the Numerical Electromagnetic Code - Basic Scattering Code (NEC-BSC)[4] is used. NEC-BSC uses the Uniform Geometrical Theory of Diffraction (UTD) to determine the antenna radiation patterns in the presence of complex structures. For NEC-BSC the ship is modeled using solids such as plates, cylinders, and ellipsoids which are created and visualized using the NEEDS-BSC workstation. The NEEDS-BSC workstation is also used to visualize the outputs from the NEC-BSC.

Computing the EM characteristics of the ship is computationally intense and is typically run on high-performance computing (HPC) platforms. Rendering results is best done on systems with hardware graphics acceleration to allow fast rotation, translation, and zoom.

The near field computation (figure 2) is used to identify areas of concern for HERP (Hazardous Electromagnetic Radiation for Personnel) and HERO (Hazardous Electromagnetic Radiation for Ordnance). Areas of concern (high intensity) are identified in two ways: density of the point cloud and color coding. The software also has a high pass filter (or threshold); allowing users to focus on areas around the ship of greatest concern.

Far fields (figure 3) show how evenly an electromagnetic signal is transmitted from a ship's antenna. The distance from the origin to a point on the surface of the image is

proportional to the field magnitude. A perfect far field image would be a hemisphere. Some causes of variation from a hemisphere include physical obstructions and electromagnetic interference. Color is used to depict phase.

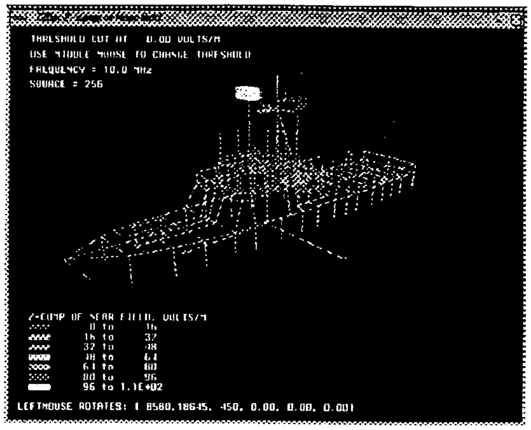

Figure 2: Near field NEC model of a Coast Guard Cutter

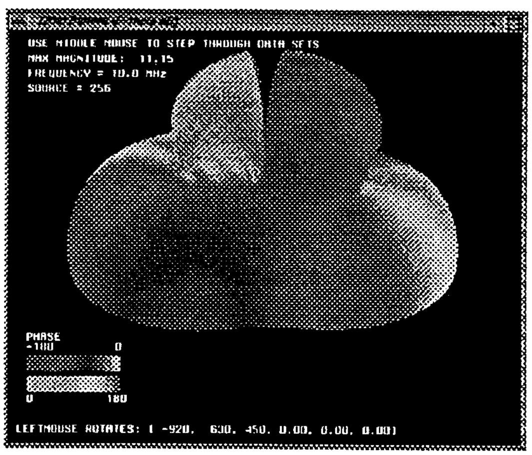

Figure 3: Far field NEC model of a Coast Guard Cutter

NEC Applications

A NEC-BSC model (Numerical Electromagnetic Code - Basic Scattering Code) was used to generate a volumetric radiation pattern using the ground data terminal develop by NRaD to analyze the radiation pattern performance of the unmanned aerial vehicle, the Electronic Warfare (AN/SLQ-32), and the cooperative engagement capability (CEC) systems on the USS TARAWA. Computer modeling of antennas has become a powerful and widely used tool for the design of antennas. Under the NAVSEA Electromagnetic Engineering (EMENG) program, several computer tools have

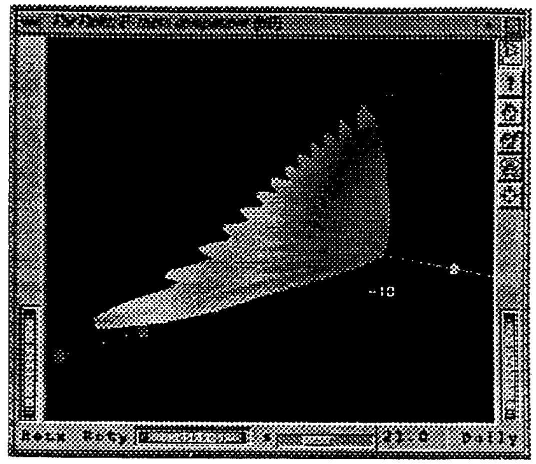

Figure 4: 3D display of the vertical components of the fan at 5 mHz

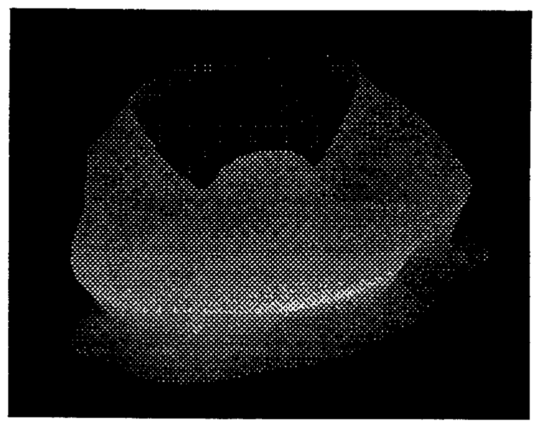

Figure 5: Volumetric radiation pattern of the GDT directional antenna in free space.

been adapted for designing the exterior RF communication, Electronic Warfare (EW), and radar systems for Navy ships. The two principal computer design aids are the Numerical Electromagnetic Engineering Design System (NEEDS) and the Co-site Engineering Design System (COEDS). The NEEDS workstation supports the topside designer in determining the antenna performance. The COEDS workstation supports the topside designer in the electromagnetic Compatibility (EMC) analysis

of the communication, EW, and radar system in the co-site environment. For example, in reference to USS TARAWA, the NEEDS tool (NEC-BSC) was used to represent the vertical components of TARAWA's fan antenna at five mHz (figure 4). Also, NEEDS-BSC[5] is used to

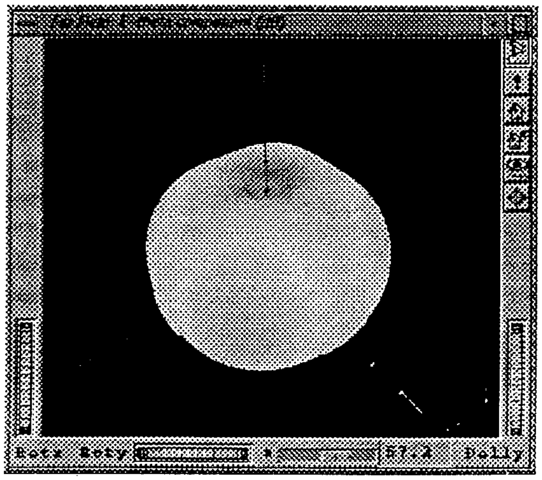

Figure 6: Calculated volumetric radiation pattern of the GDT omni-directional antenna in free space.

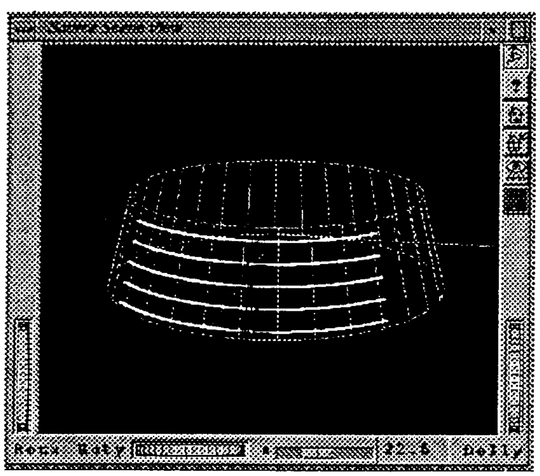

Figure 7: NEC-BSC model of the CEC active phased array antenna

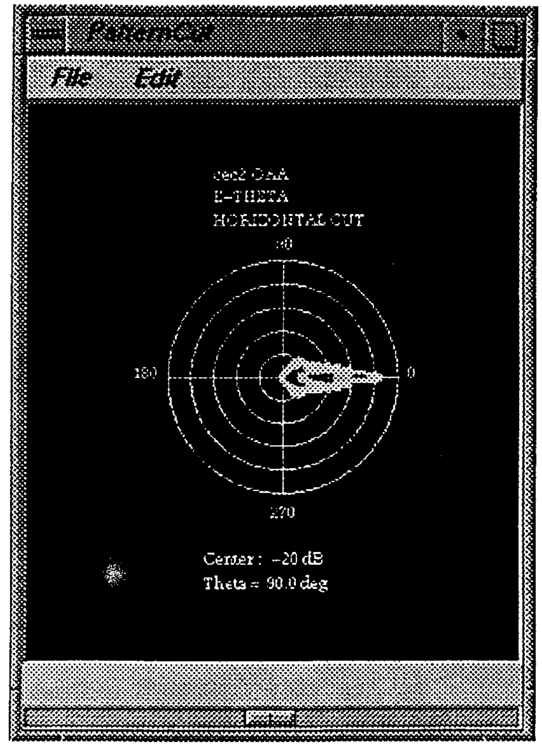

Figure 8: Azimuth cut through the main beam of the CEC active phased array antenna in free space.

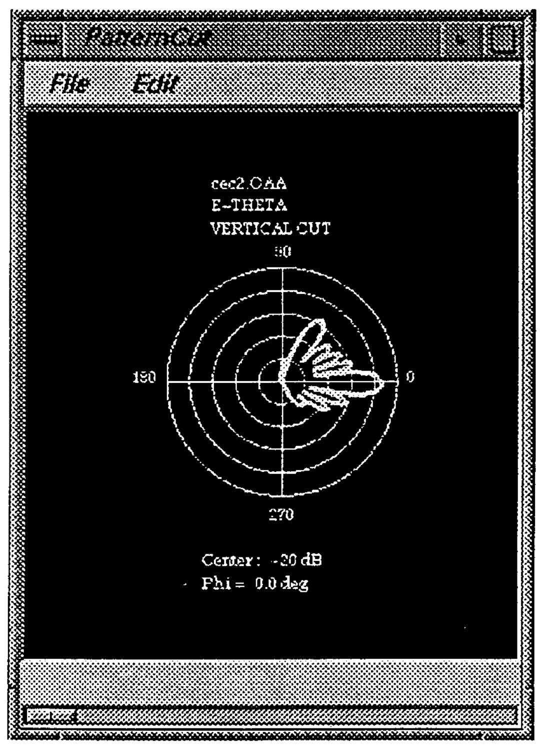

Figure 9: Elevation cut through the main beam of the CEC active phased array antenna in free space

predict the JTUAV GDT and CEC antenna performance in free space and in the shipboard environment. The free space volumetric radiation pattern of the JTUAV GDT directional antenna is shown in figure 5.
As noted in the NRaD JTUAV/SV Topside EMC Analysis of the USS TARAWA (LHA-1) report, the NEC-BSC is a uniform geometrical theory of diffraction base program that is used to analyze the radiation pattern of antennas in complex shipboard environments (figure 6 (9)).

Additionally, a NEC-BSC CEC antenna model was created by placing the electric current elements near the surface of a cone frustum in five rows of 120 elements over a 90 degree sector (figures 7-10 show active phased array CEC antenna in free space). The magnitudes and phases of the current elements are chosen to produce a uniform phase front in the main direction.

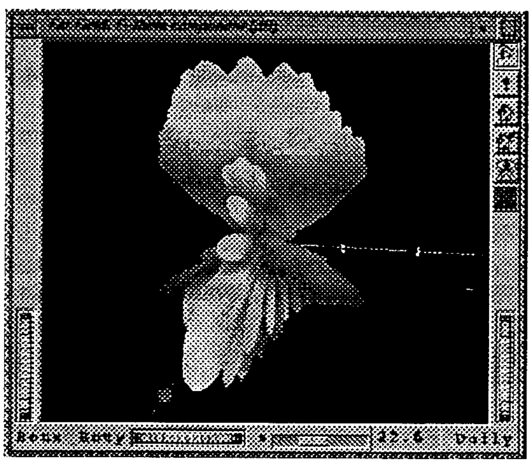

Figure 10: Volumetric pattern of the CEC active phase array in free space

Today, Topside Design uses the Navy Shipboard exterior RF system design approach for electromagnetic compatibility assessment work. Given a proposed design in a RF system diagram, a topside designer sets requirements on the coupling or isolation between transmit and receive or transmit and transmit antennas. The required antenna isolation is to make the undesired power less than the maximum tolerable level for specified receiver performance. By comparing the required antenna isolation with the achieved antenna isolation, the topside designer determines whether additional isolation between transmit and receive antenna is necessary to obtain an electromagnetically compatible system.

RAY TRACING and CASTING TECHNIQUE

The Ray Tracing and Casting technique was developed to assist the Navy's Electromagnetic Engineering with microwave energy propagation prediction in a shipboard environment. In viewing the Ray Tracing and Casting data, visualization of diffracted ray paths from a back lobe scattering source with 2D graphics was very difficult. Today with the help of 3D graphics, it is possible to view a complete display of a ray tracing /casting including any type of diffracted output data. Ray tracing and casting was also developed to visualize and quantify microwave frequency electromagnetic energy propagation. It employs ray tracing and casting techniques, geometry optics, and the Uniform Theory of Diffraction as its main engine. Microwave frequency electromagnetic energy propagates much like light in a topside geometry. Because the wavelength of the energy is short compared to the dimensions of the topside geometry, "shadows" are cast by the geometry. Figure 11 shows how EM fields can be predicted by simulating light traveling as if the ship's topside was build from mirrors. Figure 12 is a 3D plot of a map of power densities over a rectangular area. It shows how to arrive at a quantitative prediction for the E-field at the observation point.

GMULT/GCOUPL

GMULT is used to quantify an antenna gain loss (as a function of pointing angle) and pattern degradation (at user's specified pointing angle). It was developed to predict the shipboard electromagnetic environment, antenna coupling, and pattern performance when a microwave antenna is operating. The GMULT technique computes the antenna pattern for antennas operating in the presence of multiple shipboard obstacles located in the near-field or far-field of a victim antenna. The GMULT technique main

engine is based on the Spherical Aperture function.

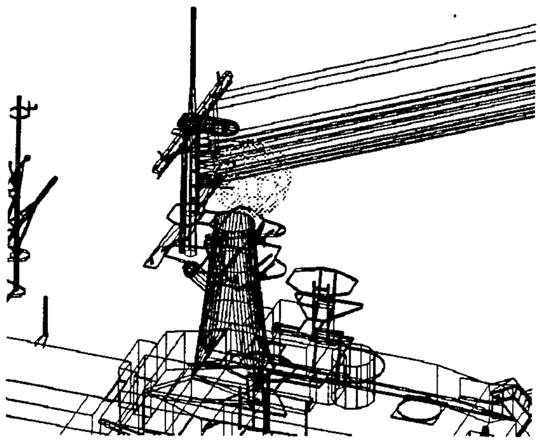

Figure 11: Ray Tracing of CG's Antennas

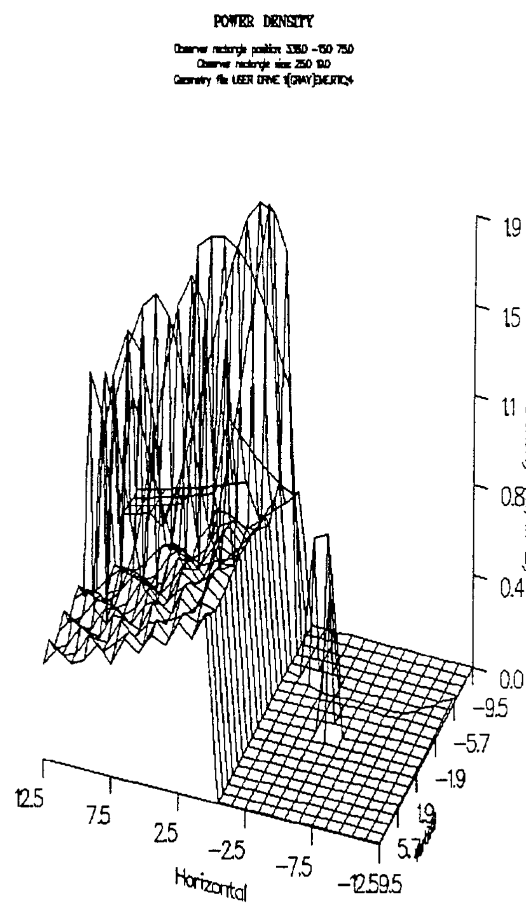

Figure 12: 3D Power Density Plot

GMULT was utilized to compute the gain loss and patterns for the CEC antenna that will be installed on a recent NAVSEA ship design. A candidate arrangement for the CEC antenna is depicted in figure 13. The CEC antenna is blocked in the aft sector primarily by the AN/SPS-48E antenna, the pedestal for the SPS-48E, and the IFF circular array; the SPS-48E antenna rotates during its operation and, hence, it presents a varying cross-section to the CEC antenna. In order to bound the blockage effects, GMULT was used to compute the gain loss and the blocked patterns of the CEC antenna for broadside and edgewise orientations of the SPS-48 antenna with respect to the aft direction, as illustrated in figure 14. Plots of the one-way mainbeam gain loss for the CEC antenna operating in the presence of these dominant blocking obstacles are shown in figure 15 for the SPS-48E antenna oriented broadside and edgewise to the CEC antenna. Plots of the blocked azimuth and elevation patterns for broadside and edgewise orientation of the CEC antenna are shown in figures 16 through 19.

According to the report (10), the maximum gain loss varies for broadside orientation of the SPS-48E antenna to the edgewise orientation of the SPS-48E antenna. Inspection of the patterns plotted in figures 16 through 19 shows that the pattern degradation is prohibitively severe for useful operation of the CEC antenna in central region of the aft angular sector. As a result, it is recommended that the aft looking CEC antenna be relocated to a platform on the aft side of the same mast as the SPS-48E antenna in order to provide an unobstructed view of the entire aft hemisphere.

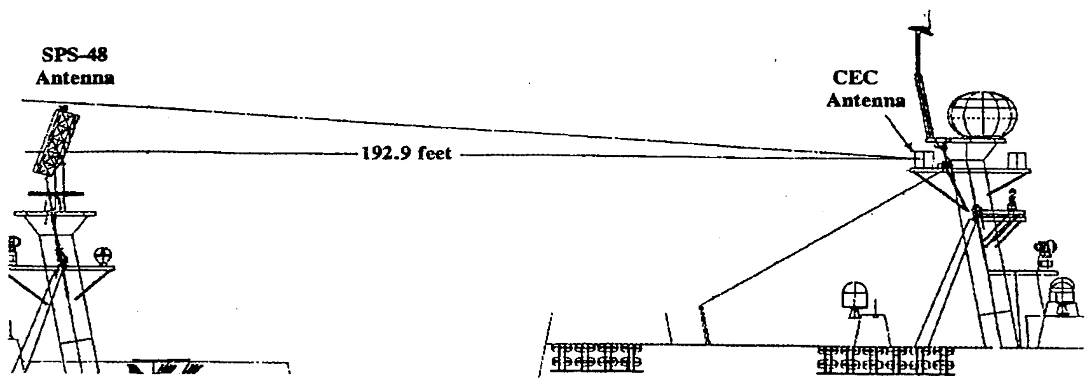

Figure 13: Arrangement of a CEC Antenna and a SPS-48E antenna

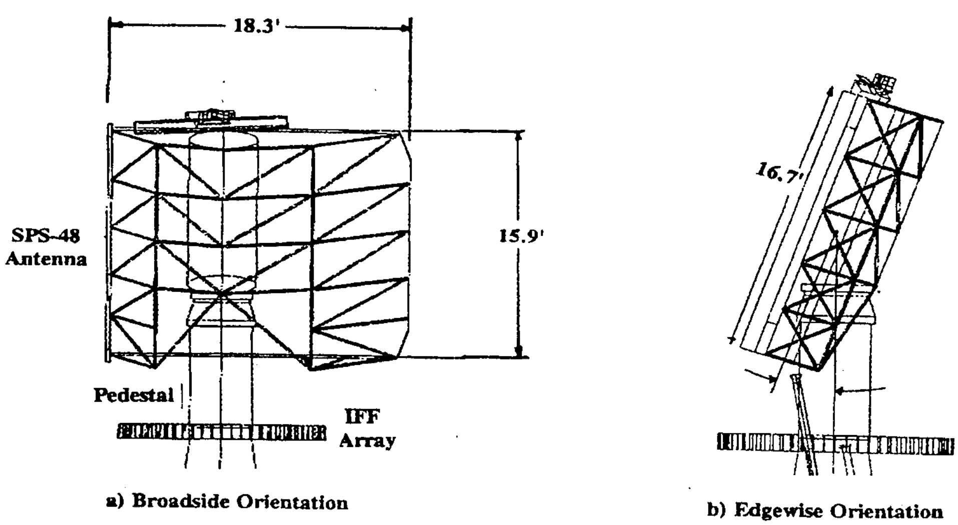

Figure 14: SPS 48E antenna, the pedestal, and the IFF circular array

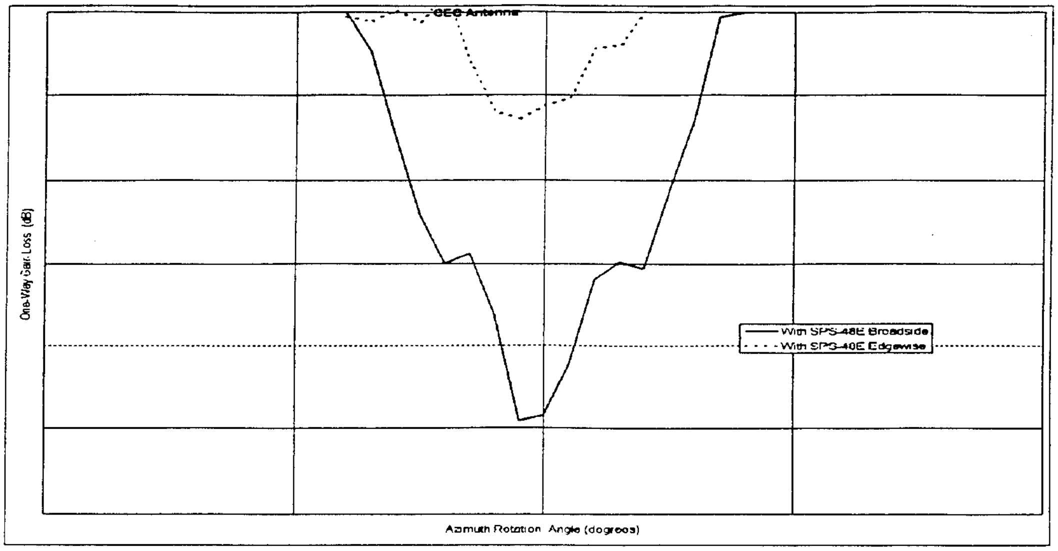

Figure 15: One-way mainbeam gain loss versus azimuth rotation angle of the CEC antenna, for blockage by the SPS-48E antenna, the pedestal, and the IFF array, for the two indicated orientations of the SPS-48E antenna.

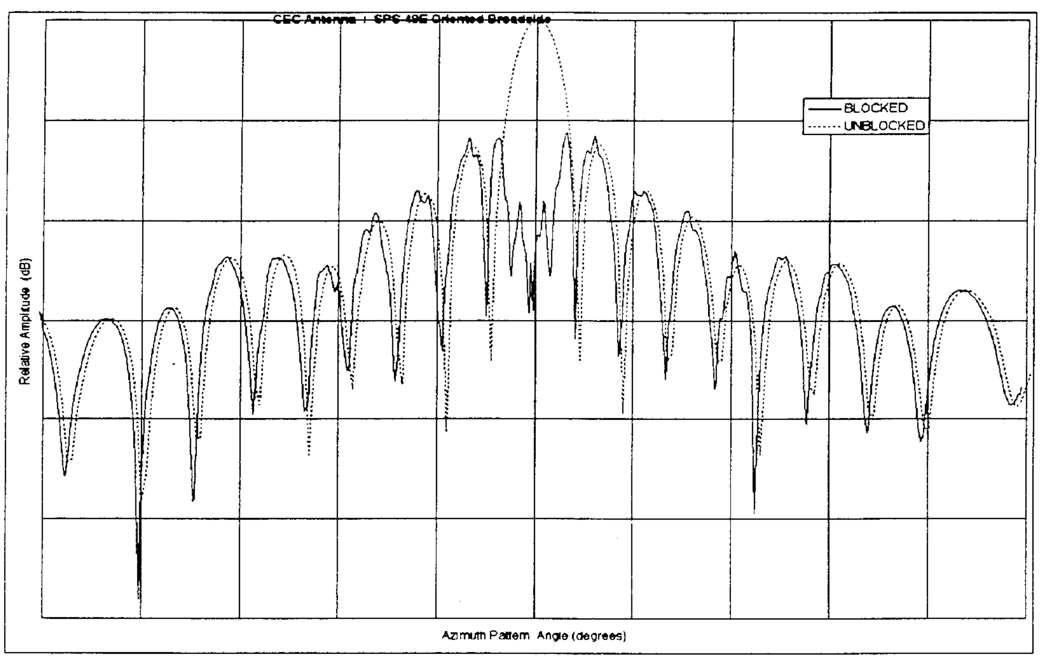

Figure 16: Unblocked and blocked azimuth patterns for the CEC antenna for broadside orientation of the SPS-48E antenna.

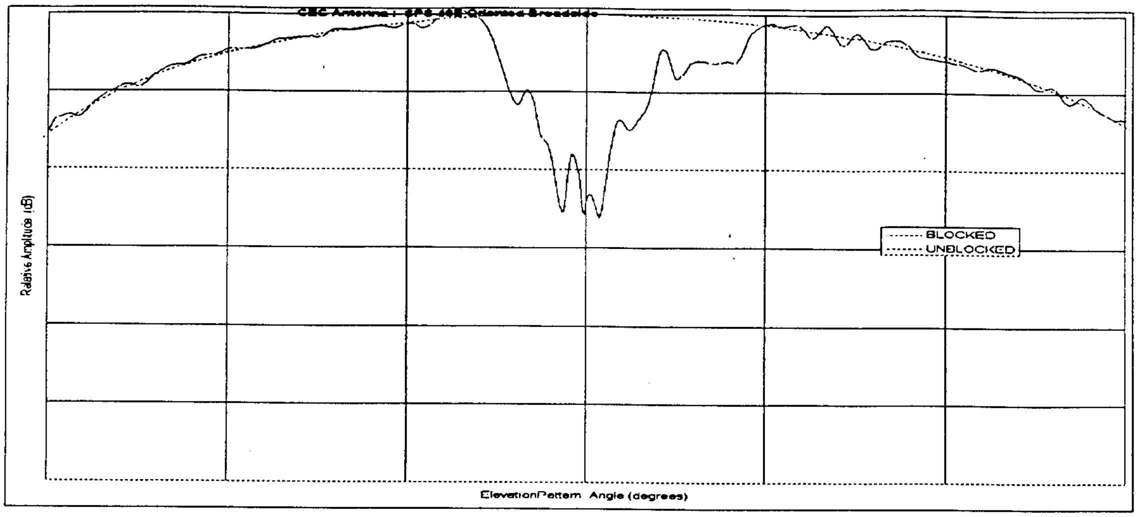

Figure 17: Unblocked and blocked elevation patterns for the CEC antenna for broadside orientation of the SPS-48E antenna.

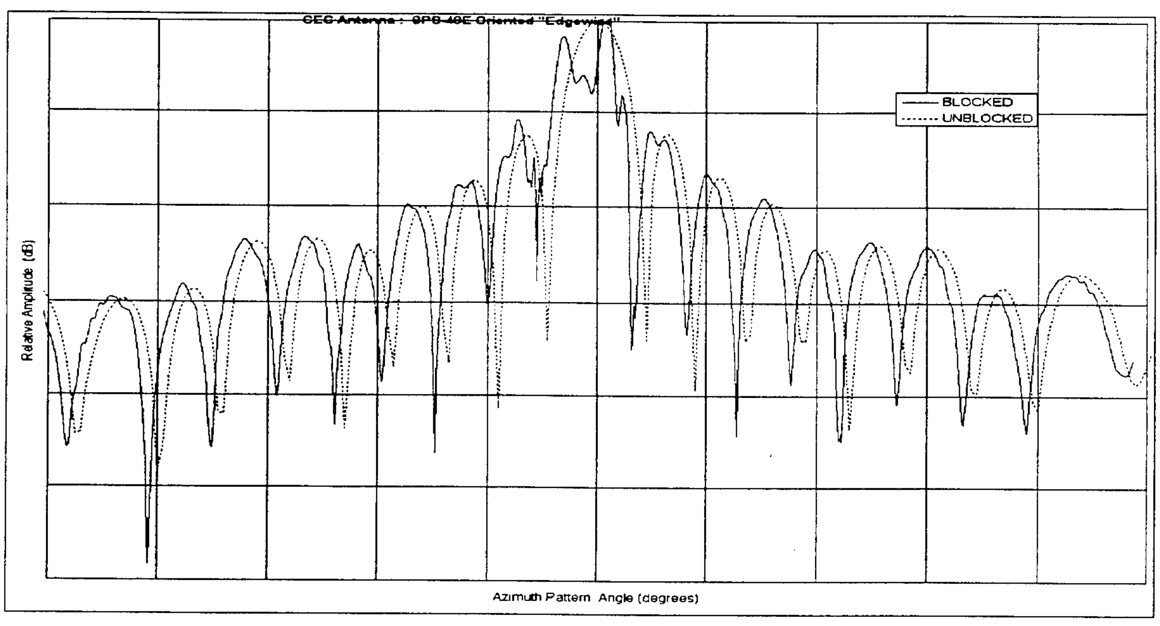

Figure 18: Blocked and blocked azimuth patterns for the CEC antenna for edgewise orientation of the SPS-48E antenna.

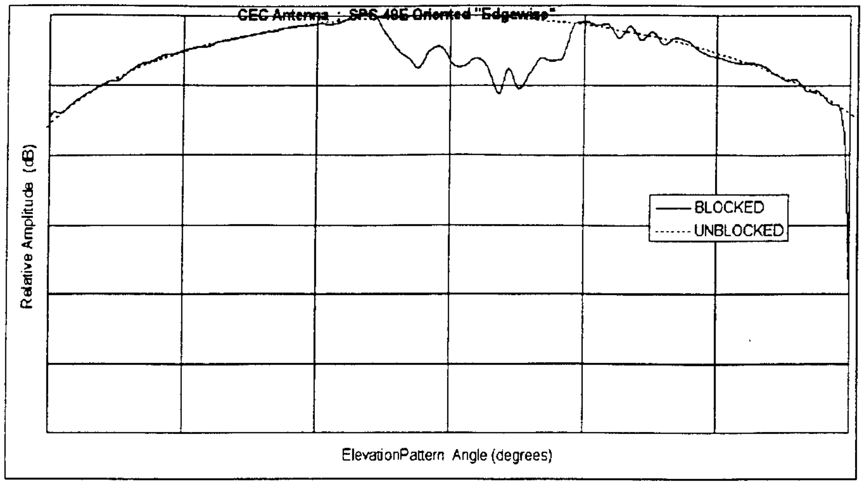

Figure 19: Unblocked and blocked elevation patterns for the CEC antenna for edgewise orientation of the SPS-48E antenna.

Future Requirements

The EM Engineering workstation of the future must provide intuitive and interactive insights into EM Design. To realize this vision, a number of enhancements will be required:

Faster Application Submodules. Running EM Engineering models often takes days. Far from "interactive;" much faster methods of solving these models must be found. Admittedly, interactive response is a stretch goal. EM Engineering algorithms are similar to weather algorithms - additional speed is often consumed by finer resolution. However, faster execution - used for either quicker response or finer resolution - benefits any application. NAVSEA is currently investigating distributed parallel processing. Although not as powerful as high performance computing platforms, using spare bandwidth on computers distributed across a network should provide cost-effective speed improvements to EM Design.

Greater use of advanced graphics techniques. Animation, Solid/Translucent representations of volumetric data, and tighter integration with the NAVSEA CAD environment are some of the graphics enhancements under investigation. These enhancements, requiring very fast graphics rendering, will provide much greater insights into EM Design.

Faster Software Development Cycle. Budget constraints and new requirements will require the use of high level tools to quickly prototype and develop software required to design a ship in the twenty-first century. Visual programming languages, X11 and Microsoft Windows graphical user interface builders, high level graphics libraries, and high level mathematical analysis tools are currently under investigation.

Continued use of Open Software. NAVSEA will continue to insist upon open software - software that runs on a variety of operating systems (major UNIX platforms, Microsoft Windows NT). By adhering to a policy of "no proprietary tools," NAVSEA has successfully supported its EM Engineering customers' heterogeneous computational environments. Although the EM Engineering environment is very portable and used the best tools available when it was developed; NAVSEA continues to search for better ways to develop software. New software tools such as OpenGL, Open Inventor, and IBM Data Visualizer show promise in providing high performance graphics on a wide variety of computer hardware with a far shorter development cycle.

New Models. Other EMENG tools are being developed to handle shipboard composite material and multi-function apertures, low observable stack, and composite embedded antennas.

Conclusion

This paper describes techniques by which an engineer can systematically design a ship's topside, and presents the reader with an appreciation of the complex electromagnetic environment that surrounds Navy ships. We have described a panoramic series of EMENG tools needed to assess and help reduce EMI during the ship design processes. Also described are new challenges that lie ahead. The Navy must continue to aggressively pursue the best computational tools available today to meet the challenge of designing surface combatants of the future.

Acknowledgments

We gratefully acknowledge Linda Russell, Daniel Tam, and John Meloling (NRaD), Larry E. Gray (Rockwell International), and John P. Estrada (Georgia Tech Research Institute) for providing valuable information used in the development of this paper.

Endnotes

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[1] John A. Winston; "EM Engineering System Architecture", pg 2, Rockwell International
[2] InterGraph/CLIX is InterGraph's port of UNIX to their proprietary *Clipper* processor.
[3] NEC-MoM was developed by Lawrence Livermore National Laboratory
[4] NEC-BSC was developed by Ohio State University.
[5] NEEDS-BSC is under development by NRaD with expected funding from NAVSEA in FY96.

6. Neil T. Baron & Donald Cebulski, "EMI The enemy Within" presented and published at the 28th Annual Technical Symposium of the Naval Sea Systems Command Association of Scientists and Engineers, 11 April 1991.
7. James C. Logan, Shing Ted Li, and Irving C. Olson, "A role model for electromagnetic systems design", IEEE Potentials, December 1988.
8. "Ray Tracing and Casting User's Manual" prepared by Rockwell International under NAVSEA contract, December 1995.
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10. "Spherical Aperture Analysis of Shipboard Directive Antenna Performance and Coupling" prepared by Georgia Tech Research Institute, January 1995.

Biography

CDR Steven Z. Elbinger serves as a Naval Reserve Engineering Duty Officer supporting the Combat Systems branch of NAVSEA Headquarters. In his civilian career, Mr. Elbinger is a senior software and metrology engineer at Hewlett-Packard's Ink-Jet Division where he designs control systems and automated metrology tools for laser machining equipment. Previous assignments include development of the HP Pascal language on HP-UX and kernel, networking, and language development on HP's BASIC Workstation.
Mr. Elbinger graduated with honors from the University of Southern California with a B.S. in Computer Science. In 1989 he received a M.S. in Computer Science from the National Technological University. On active duty, he served on the USS RICHARD S. EDWARDS (DD 950); qualifying as a Surface Warfare Officer. Mr. Elbinger is a member of the IEEE Computer Society and the American Society of Naval Engineers.

Ramses Routier works as an Electronic Engineer at NAVSEA 03K24 topside design branch. He is currently working on Destroyers and auxiliaries in the area of topside design. He also works on developing Electromagnetic Engineering tools to handle shipboard EM interference between systems in the microwave region.
MR. Routier graduated in 1988 from the City College of New York with a B.E. in Electrical Engineering. He currently working toward a master degree in Electrical Engineering specializing in Electro physics from the George Washington University. Mr. Routier is a member of the ASE and the IEEE Society.

Do Management Information Systems Replace Middle Managers?

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Director Fleet Support Liaison Office
SEA 03D9
Naval Sea Systems Command

The views expressed herein are the personal opinions of the author and are not necessarily the official views of the Department of Defense or the Naval Sea Systems Command.

Abstract

In recent years much of management's time is spent discussing how to accomplish the Navy's engineering work with fewer layers of management. American industry has faced similar reengineering from which we might draw some lessons. The paper reviews the influence that management information systems have had on middle managers in large corporations. A chronology of changing management theory, driven by economic pressure, traces how middle management became a problem and information technology was the chosen solution. The discussion includes: opinions of the business press and management theorists, conclusions from industry surveys, and government data. The paper closes with an optimistic outlook for middle management.

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Levitt and Whisler predicted that widespread applications of information technology would practically do away with middle management as they knew it in 1958.[2]

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In the 50s and 60s, the major concern of manufacturing was capacity, i.e., the ability to keep up with demand. When Alfred Sloan took over General Motors, he created the prototype decentralized management system. The resulting decentralized, pyramidal organization was well suited to planning and controlling large work forces as well as expansion. The population growth in middle management is attributable to the limited span of control and multiple management layers characteristic of the hierarchical structure.[5]

Today, Leavitt and Whisler are frequently recognized in business literature for their prophetic vision. However, Leavitt and Whisler's 1958 prediction met strong criticism through the 1960's, 1970's, and early 1980's.[6]

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Environmental changes focused attention on the shortcomings of middle management. Some companies reorganized and retrained to correct the problem while others grew more frustrated with the middle managers.[9]

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Corporations followed Kay's suggestion and applied technology to their middle management problem. Martin Lasden concluded in 1983, "It's the severity o contemporary crises, not the imminence of new technology, that is prompting most of the profound corporate changes we're seeing....In the midst of these crises, corporations are discovering the power c information technology to effectively implement the needed reforms. The technology comes, then not as the chief threat to a thriving status quo, but as the savior to dying companies."[10]

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Downsizing and "flattening" have been common in the past sixteen years. Organizations shed more than one million managers and staff professionals from 1979 to 1988.[13] Middle management accounted for one fifth of the job losses in the United States from 1988 to 1995.[14] As companies reduced the number of middle managers, senior managers have increased their span of control and assumed additional responsibilities.

Impact of Automated Information Systems on Middle Managers

Early data-based information systems served to isolate middle managers and focused their attention on the "numbers" as the only thing that mattered. In poor organizations, middle mangers were not provided the breadth and depth of data they needed to participate in decision making so they felt isolated. The data systems actually aggravated their apparent poor performance.[15]

Ghassan A. Alshibl, a doctoral candidate at The George Washington University, surveyed 260 middle managers and interviewed two vice presidents at eight Fortune 500 companies with well established and integrated Automated Information Systems (AISs) [included office automation].[16] The following conclusions were drawn from his 1990 survey results:

1. AISs reduce the time required by middle managers to perform their four basic activities [planning, decision making, communication and controlling] up to 25 percent.
2. Middle managers have written formalized procedures for performing their basic activities and up to 25 percent utilize AISs performing these activities.
3. AISs do not reduce face to face communications between middle managers, their colleagues, their subordinates, and their superiors.
4. Middle managers are delegating routine and repetitive work to their subordinates as a result of using AISs and the middle manager's work is becoming interesting and satisfying. Middle managers have more time for creative thinking, decision making, and problem solving.
5. The use of AISs causes a significant increase in the amount of direct communication between top and lower levels of management, thus bypassing middle management.
6. The majority of respondents believe the use of AISs have a very low to moderate impact on their organizational structure and their work as middle managers.
7. AISs significantly widen the span of control of middle managers.
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His survey did not single out a specific cause for the reduction in middle managers but the possibilities included a) automation of manager's work, b) resistance to automation, and c) budget cuts by the organization. Fourteen percent of his respondents reported increases in middle management attributed to AISs.[17]

In summary, in corporations with well established information systems, AISs do reduce the number of middle management positions. However, there is also evidence of a positive effect on the work of the remaining middle managers including a wider span of control, and more time for creative thinking, decision making, and problem solving.

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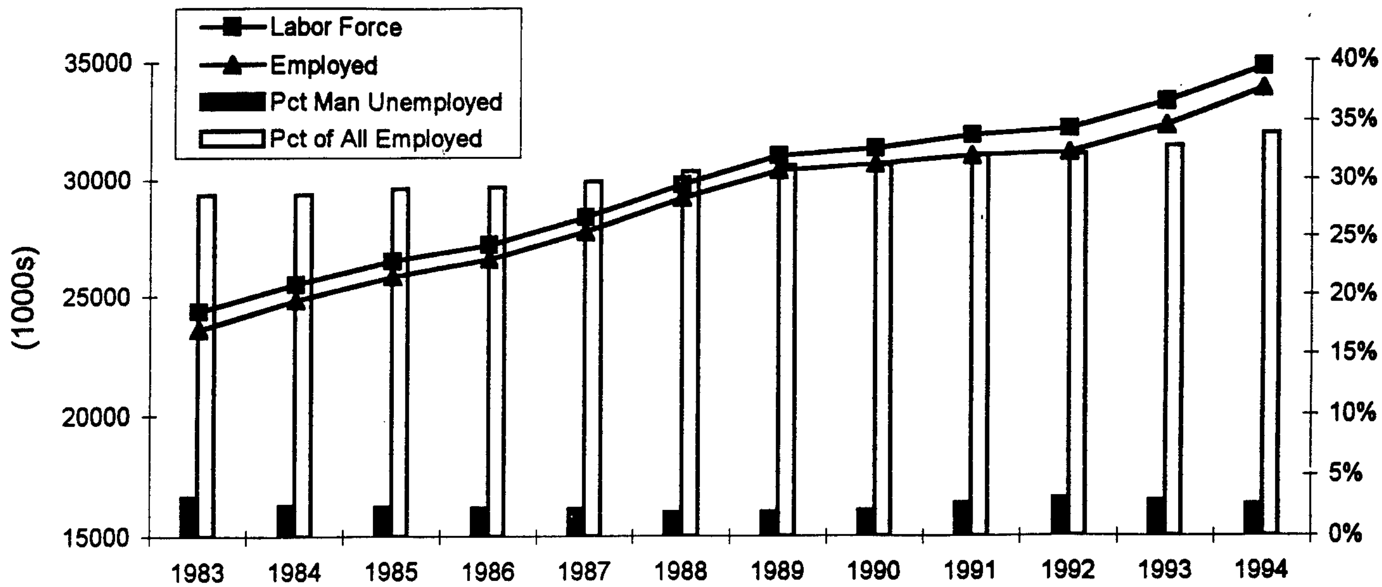

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Endnotes

[1] H.J. Leavitt and T.L. Whisler, "Management in the 1980's," Harvard Business Review 36 (Nov-Dec 1958): 41-48.

[2] Emanuel Kay, The Crisis in Middle Management (New York: ANACOM, 1974), 126-27.

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[13] Applegate, 128-36.

[14] "The salaryman rides again," Economist 334 (4 February 1995): 64.

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[16] Ghassan A. Alshibl, "A Study of the Impact of Using Automated Information Systems on Middle Managers" (Ph.D. diss., The George Washington University, 1990), 13-14, 87-180.

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[19] David Jackson and John Humble, "Middle Managers: New Purpose, New directions," Journal of Management Development 13.3 (1994): 15-21.

Biography

***Captain Charles H. Wilson** was commissioned in the U. S. Navy in 1970 upon earning his Bachelor of Science in Electrical Engineering from the University of Idaho. He completed his Master of Science in Engineering Electronics with distinction at the Naval Postgraduate School in 1976. He is a graduate of the Defense Systems Management College and completed the Program for Executives at Carnegie Mellon Graduate School of Industrial Management. Captain Wilson commanded the USS Hermitage (LSD 34) and USS Acadia (AD 42). He has conducted acquisition work at both the Space and Naval Warfare Systems Command, and the Naval Sea Systems Command. He is currently a Master of Science degree candidate at The George Washington University School of Business and Public Management in the field of Management Information Systems.*

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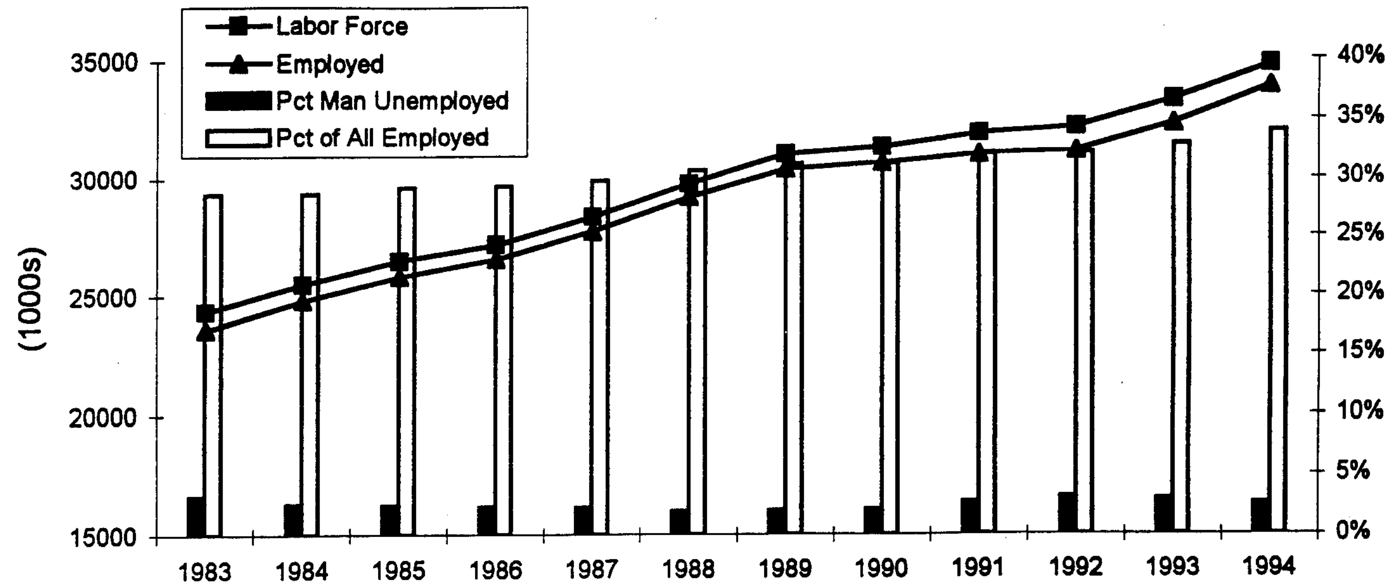

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Biography

Captain Charles H. Wilson was commissioned in the U. S. Navy in 1970 upon earning his Bachelor of Science in Electrical Engineering from the University of Idaho. He completed his Master of Science in Engineering Electronics with distinction at the Naval Postgraduate School in 1976. He is a graduate of the Defense Systems Management College and completed the Program for Executives at Carnegie Mellon Graduate School of Industrial Management. Captain Wilson commanded the USS Hermitage (LSD 34) and USS Acadia (AD 42). He has conducted acquisition work at both the Space and Naval Warfare Systems Command, and the Naval Sea Systems Command. He is currently a Master of Science degree candidate at The George Washington University School of Business and Public Management in the field of Management Information Systems.

T&E ROULETTE, WHERE IS THE SMART BET?

George Axiotis
NAVSEA Test and Evaluation Office (SEA 91T)
Naval Sea Systems Command

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The views expressed herein are the personal opinions of the author and are not necessarily the official views of the Department of Defense or the Naval Sea Systems Command.

Abstract:

The primary purpose of Test and Evaluation (T&E) is to reduce risk. Given today's reduced budgets and restrictions on testing; where should a program's test manager bet his limited test resources? One cannot afford to play roulette with testing given the cost of coming to the T&E table. All testing provides insight and helps identify "unknown-unknowns". When faced with financial or a schedule constraints, testing is usually cut horizontally attempting to cover as many different test requirements at the expense of depth. We have reached a point where we must test smarter. We need to pick the right assessment tools to make vertical cuts in our test strategies. Where should the T&E bet be made for the maximum payoff?

Once a system has reached a level of maturity to be field tested the question becomes one of what types of tests should be conducted? Should one field test the difficult - and costly - scenarios and model the simple; or visa-versa. Conventional wisdom currently favors the former. This paper proposes that more "simple" testing within the expected realm of performance is a smarter bet than fewer, more complex tests to overall program risk and completion of the test program.

Figures and Tables:

Abbreviations:

ASW	Anti Submarine Warfare
CNA	Center for Naval Analysis
DOD	Department of Defense
M&S	Modeling and Simulation
T&E	Test and Evaluation

When Should I Test?

The primary role of Test and Evaluation (T&E) is to assess technical risks and minimize those risks with feedback into the engineering process. T&E is the critical assessment element within the DOD acquisition process. As such, all testing is considered valuable; first, to affirm expected performance and secondly, to help identify "unknown-unknowns". The expectations today are to inject as much realism into our field testing (a generic term used to describe testing of a mature item in a realistic environment) to stress the system throughout its performance regime. Unfortunately as realism increases, conducting the test may become more of a driver than the value of the outcome.

For a typical test program shown in Figure I, we see tests grouped at the center of the expected performance region with excursions to the limits. As the cost of testing in the field increases, the ability to perform these excursions decreases. The T&E manager must rely on other analytical methods, such as modeling and simulation (M&S) to help populate the envelope. This paper focuses on one aspect of test planning, namely the decision whether or not to perform complex testing in the field. Today, we tend to model the expected performance and save field testing searching for "unknown-unknowns". It will be argued that when faced with a tradeoff, it is frequently better to perform many "simple" field tests and save the complex scenarios for modeling or simulation.

This paper examines aspects of testing in the field and M&S to determine which tool is best suited for which job. No attempt will be made to relate the relative value of attempting or failing a test. This paper will focus on the Test or No-test decision. It will be surmised that keeping field testing simple allows you to meet test objectives quicker with a higher probability of meeting overall program goals. Additionally, that testing in realms at or beyond the

threshold are better suited for M&S. When faced with an option, it is recommended that more "simple" field testing within the expected realm of performance is a smarter bet than "complex" testing.

T&E Realities

A good test manager tests throughout the expected realm of performance. The threshold is by definition the minimum performance requirement to field the system, thus expectations are that all testing be conducted at or just beyond threshold limits. Unfortunately when faced with programmatic constraints, T&E, either in scope, resources or schedule are routinely sacrificed. These constraints are not only the fiscal resources to conduct testing and procure test articles, but also asset availability to support the event. Additionally, local political and environmental concerns are limiting where testing can be conducted. Horizontal cuts are made across the test matrix to maintain breadth at the expense of depth.

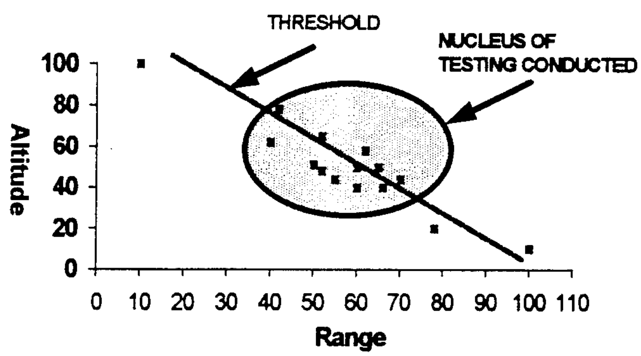

Figure I - Generalized Plot of Testing

Fortunately for the test manager, there are new trends in acquisition management which will help rethink how T&E is planned. Models, simulation and analysis are being better utilized in filtering approaches before committing limited resources into building and testing prototypes. No longer will one have to wait for T&E to answer fundamental design questions. Additionally, the milestone decision authority is accepting higher levels of uncertainty. Statistical confidence is no-longer a driver and decisions can be made by examining data from various sources such as analysis, modeling, simulation, and sub-element tests in addition to field tests.

What this implies is that once the commitment is made to build prototypes, field testing can now be focused on where it is absolutely required. The trick is deciding what types of tests are to be conducted

Complex Field Tests Cost More

There is nothing illogical about increased complexity costing more. But is the outcome worth the cost? Field testing can be conducted on or off a range. The field introduces elements into the test which cannot be easily simulated such as environmental effects, system and subsystem interactions and human behavior. For the purposes of this analysis, field testing is grouped into two very broad, and subjective categories; simple and complex. A simple test is one where the event is conducted within "normal" capabilities, methods and tactics and does not require changes to safety, control procedures or management processes to accomplish the event. The primary goal of a simple test is to assess the test article itself with less emphasis on secondary interactions. These tests generally reaffirm expected performance predictions. Conversely, a complex test introduces more elements to assess interactions whether or not directly linked to the test article itself. Examples of complex tests are: two or more incoming missiles against a defending target; submarine evasions outside the submerged operating envelope; charge size requiring new environmental assessments; ASW prosecution in torpedo development.

In these examples, the effort required to successfully plan, set-up, coordinate, run and analyze the test event exceeds that under normal conditions. This complexity has a direct relation to cost. For example, in support of a torpedo upgrade program, up to ten torpedoes could be exercised per day on range if the scenarios preposition the shooter and target at time of fire. But possibly only three events could be attempted if the shooter is required to detect and track the target before firing. The test cost increased three-fold by incorporating ASW prosecution into the scenarios. The increased complexity increase understanding of the entire ASW engagement, but it detracted from assessing torpedo logic. It is safe to conclude that as test complexity increases, programmatic expense (in terms of time, cost and risk of completion) increases, but without necessarily a corresponding increase in understanding of the article under test.

Cost Means Risk

Is there a correlation between increasing the cost of testing and the ability to meet overall test goals? In a 1995 paper, Dr. R. Bruce Parry presented a model which showed that testing can be minimized by assessing the probability of successfully conducting the test based on cost. Analysis showed that for one-shot test events, such as bullets, bombs and missiles, the more expensive the test, the cost (in terms of achieving overall test goals) of failure (poor test attempt or failed test) increased. Costs are weighted by the probability of the cost being incurred by failing a test. These "costs" are not only the direct cost of the test itself (assets, range time, fuel, etc.) but also living with the results. Generally speaking the cost of incorrect evaluation (passing when it should be failed, or failing when it should be passed) exceeds the cost of correct evaluation (passing when it should be passed, or failing when it should be failed). The probability model analyzed past test history to determine if testing should continue, stop with system pass, or stop with system failure Figure 2 graphically depicts a generalized output of the behavior of the model used in the analysis. The regions are defined as follows:

Pass - Indicates that one should quit testing and pass the system

Test - Indicates that one should test further

Fail - Indicates that one should quit testing and fail the system

Optimal Test Strategy Behavior

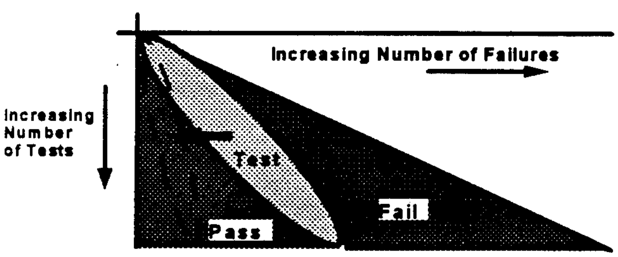

Figure II - Narrowing and shifting of the "Continue Test" region as cost-to-test increase. Based on "Testing to Minimize Expected Costs", By Dr. R.B. Parry

It was shown that the Test (uncertain) region narrowed and shifted to the left as test costs increased and that the region of Pass (acceptance) region decreased. The Test region also necks down as the number of tests increases. As the cost per test is raised, it ultimately becomes too expensive to test the system and one uses what data is on hand to assess the system. Conversely as the cost of the test is lowered, one could test to system pass or quit and declare success earlier and minimize total expected cost. The author recommended that a test manager use a probabilistic based approach to minimize the expected total cost rather than to some fixed statistical pass threshold criteria. It can thus be shown analytically that a more costly test increases the risk of not meeting test requirements.

Complexity is Risk

Can the "one-shot" test of the above study be correlated to a complex test? It is true that as test complexity increases, the management attention necessary to execute the test event also increases. Over time, the attention and effort to accomplish the complex test may even surpasses the value of the results. The complex test begins to mimic the one-shot events addressed in the above study in two major ways: First, in a one-shot test, the test item is consumed. Test article costs cannot be amortized with reuse. Similarly, as complexity increases, the resources necessary to execute the event cannot be easily "reused" to get back the return on the investment. This is evident in complex combat systems tests where weapons, targets and countermeasures are consumed. Secondly, even if consumables were reusable, the ability to replicate a complex event (setup, timing, reaction) for comparison purposes or to build a data base, decreases. As complexity increases, the event becomes unrepeatable. It can be safely stated that the least cost test strategy model above can be applied to complex tests. The logical conclusion is that simpler tests allow you meet overall test goals sooner with a higher probability of success.

Comfort With M&S

M&S used to support T&E evolved from Engineering/Design models. Because of where T&E

falls in the development process, it has never been a driver in M&S development. T&E capitalized on investments made in other disciplines and adapted the product for its own use. The T&E M&S fidelity and timing requirements mimic those for Engineering more so than for training M&S. It is no wonder that when we adapt Engineering/Design Models for T&E purposes we expect the results to be a close approximation of the expected outcome in engineering. We have developed a high confidence in our ability to mimic performance in expected realms and feel comfortable simulating simple scenarios to reinforce the expectations of design. Fortunately, the same arguments can be presented for complex testing. Scenarios can be repeated economically and variability minimized for comparison. The complexity or performance envelope can be altered in multiple iterations as "unknown-unknowns" are discovered. Scenarios can be developed that are not possible in the field and M&S can expose flaws early which would keep tests from being conducted in the first place. But to use M&S efficiently and economically, element fidelity must diminish as the complexity of the scenario grows. This fidelity is closely linked to system level maturity. As system level maturity increases, the flexibility M&S provides for probing the difficult is more advantageous than its ability to validate the obvious.

Test The Easy

A test, no matter how complex it becomes, is itself a simulation. The test is a microcosm of the real world. Since realism is equated with complexity, some see simple tests in the field as nothing more than a rigged demonstration. In reality, the test manager can gain real-world insight by keeping tests simple. System characteristics such as reliability, subsystem interoperability, utility and manufacturing variation are not easily predicted by M&S. Failures can be more easily attributed to the cause if the interactions are minimized. Finally keeping testing simple keeps them repeatable which allows performance to be validated and trends mapped. This consistency is critical to validate the M&S so they can be used in the untestable realms of the performance envelope.

Conclusions

We are enamored with the idea of the "hard" field test; to toss the kitchen sink at the system and see if it still swims. This complexity unfortunately comes with a high price tag in terms of management attention, cost and probability of failure. It has been shown that keeping a test simple allows you to test more or quit testing earlier with higher confidence and evaluate aspects of performance ill-suited for M&S. The test manager should always strive to develop a strategy which tests throughout the entire performance envelope. When faced with constraints, given all else equal, it is recommended that more simple field tests be conducted over complex ones. The consequences of not fully knowing threshold performance is lower than not validating expected performance.

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Biography:

George Axiotis is the Staff Assistant for Undersea Warfare (USW) in the NAVSEA Test and Evaluation Office. George developes and assists program managers and test directors execute T&E strategies for all USW acquisition programs. He is also the lead focal on weapons lethality policy for designated LFT&E programs. Before coming to the T&E Office, he was deputy test director for the MK 50 Torpedo program and project manager on various SPAWAR communications and COMSEC programs. George has a Masters Degree in Mechanical Engineering Design and Computer Analysis from George Washington University (1990) and a Bachelors Degree in Mechanical Engineering from University of Miami (1982). In addition to supporting NAVSEA and PEO ACAT programs, he a member of numerous policy and implementation planing groups for Navy T&E, OSD Software Development Best Practices, Modeling and Simulation for T&E, software metrics, and environmental compliance for T&E. George has lectured on T&E Management at NAVSEA, COMOPTEVFOR and DSMC.

NAVSEA SHORE ACTIVITY OCCUPATIONAL SAFETY AND HEALTH (OSH) PROGRAM MANAGEMENT

Thomas Grossman
NAVSEA Shore Activity
Environmental and Occupational Safety and Health Office
Naval Sea Systems Command

Abstract

It is Navy policy to provide a safe and healthful workplace for all personnel: military, civilian, foreign nationals, and to the extent practicable, contract employees working on board navy ship and shore activities. The maintenance of a safe and healthful workplace is a line management responsibility of command, beginning with a command statement of policy by the commanding officer and carried forth by every level of command down to the first line supervisor. OPNAVINST 5100.23 (series) is the Navy's Occupational Safety and Health (OSH) Program Manual. This Manual sets forth the Navy's OSH Program elements, drawing heavily on federal regulatory requirements, e.g. 29 Code of Federal Regulations (CFR), the U.S. Department of Labor/Occupational Safety and Health Administration (OSHA) standards to be complied with.

This paper provides an overview of the management of the OSH programs in place at NAVSEA's more than seventy (70) shore activities employing approximately 70,000 military and civilian personnel. The Navy OSH program elements are structured to accommodate the complex industrial and technical work associated with naval ship, system and ordnance construction and life-cycle maintenance performed at all Navy shore activities, to ensure that our personnel are provided with a safe and healthful workplace. This paper does not address the Navy's safety and health program for forces afloat (reference OPNAVINST 5100.19 series), explosives safety or any elements of the Navy nuclear propulsion program, although these programs share much in common with the basic Navy and NAVSEA shore OSH program.

The Workplace

The NAVSEA shore activity community is comprised of Naval Shipyards (NSYs); Supervisors of Shipbuilding, Conversion and Repair (SOSs); Naval Surface Warfare Center (NSWC) Divisions, Activities and Detachments; Naval Undersea Warfare Center (NUWC) Divisions and Detachments; Naval Ordnance Center (NOC) Divisions, Weapons Stations and Detachments; the Naval Inactive Ship Maintenance Facilities (NISMFs); and a number of separate special category activities including the Navy Experimental Diving Unit and the Aegis Combat Training Center.

Employees of NAVSEA's shore activities are engaged in a wide variety of occupations; from blue collar crafts and trades associated with shipbuilding and repair; naval gun and missile construction and repair, explosive propellant and ammunition manufacturing; to a vast array of white collar R&D, laboratory, engineering, logistics management and administrative functions.

These employees perform their jobs in a number of unusual and unconventional work environments, including: gas free engineering in confined spaces; dry-dock and in water hull maintenance and repair; test, repair and calibration in test chambers and

other temperature controlled facilities; construction, maintenance and repair from barges, floating dry-docks, special staging, rigging and platforms designed for ships, weapon systems and ordnance; tanks, pools, diving platforms and pressurized chambers; and chemically hazardous work spaces dealing with extremely hazardous and highly toxic substances and compounds.

In performing their jobs, they are exposed to a number of physical safety hazards such as moving vehicles, overhead cranes, electrical and fire hazards, noise, hearing and sight hazards, and many health hazards should they exceed permissible exposure limits, cumulative exposure limits, or toxicity levels, leading to either acute or chronic symptom development.

The Navy OSH program in place at NAVSEA shore activities is designed to protect employees from occupational hazards through a three level priority of employee, work center and process evaluation beginning with attempts to engineer or re-engineer the operation to eliminate or minimize employee exposure as the best course of action to protect the employee. If this is not possible, the next best approach to protect the employee is to adopt administrative controls that will limit the amount or degree of employee exposure (i.e., limit work time to 4 hours per day vice 8, or five minutes per hour vice sixty minutes per hour). And finally, the third and least preferred method to attempt to limit exposure is to provide the employee with appropriate personal protective equipment (PPE): head, eye, noise, and face protection including respiratory protection; gloves, aprons and other clothing and footwear protection.

Because there are problems with freedom of movement, visibility, hearing and temperature levels using PPE, there is a natural tendency to avoid wearing the PPE because of the potential or actual discomfort, loss of mobility and added preparatory time associated with "suiting up" and unsuiting.

The Navy OSH Program: Background (from OPNAVINST 5100.23D)

Navy involvement with safety and health programs parallels the beginnings of safety and health concerns surfacing and taking hold during the industrial revolution and the beginning of the twentieth century. A formal program as such began to take shape during and following World War II with the recognition of safety professionals and the establishment of industrial hygiene within the medical community. The program gained further special prominence after passage of the Occupational Safety and Health Act (OSHAct) 29 December 1970. Although the primary thrust of the OSHAct was directed at the private sector employer, Section 19 of the OSHAct directed Federal agencies to establish and maintain comprehensive and effective OSH programs consistent with the standards issued under Section 6 of the OSHAct.

On 26 July 1971, a presidential Executive Order (EO) 11612 entitled Occupational Safety and Health Programs for Federal Employees was signed. This EO stated that the Federal government, as the nation's largest employer, has a special obligation to set an example for safe and healthful employment. In this regard, the head of each Federal department and agency was directed to establish an OSH program in compliance with Section 19 of the OSHAct. However, over the next 3 years, only moderate progress was made by many Federal agencies. Consequently, Congress received considerable criticism for a perceived double standard in OSH requirements between the private sector and Federal agencies. As a result, EO 11612 was superseded on 28 September 1974 by EO 11807 which more clearly defined the scope, requirements, and responsibilities of Federal agency programs. In addition, EO 11807 tasked the Secretary of Labor to issue guidelines designed to assist Federal agencies in establishing and maintaining their programs. However, the regulatory authority of the Department of Labor was questioned by several Federal agencies and the guidelines were not issued in response to EO 11807. In order to address this authority issue, EO 11807 was superseded on 26 February 1980 by EO 12196 which again directed the Secretary of Labor to issue a set of basic program elements. On 21 October 1980, the Secretary of Labor issued 29 CFR 1960 which promulgated the basic program elements for Federal Employee Occupational Safety and Health Programs. In addition, EO 12196 directed the Secretary of Labor to conduct unannounced inspections of agency

workplaces as he determined necessary in response to reports of unsafe/unhealthful working conditions.

The Department of Defense (DOD) has issued many directives and instructions to implement the Federal guidance outlined above. Prominent among these are DOD Directive 1000.3 of 29 March 1979 (Safety and Occupational Health Policy for DOD), which outlines general DOD policy and procedures relative to implementation of the OSHAct and the associated EO, and DOD Instruction 6055.1 of 26 October 1984 (DOD OSH Program) including Change #1 of 11 April 1989, which provides more specific guidance relative to the implementation of the basic OSH program elements specified in 29 CFR 1960.

Under the provisions of DOD Directive 1000.3, the Assistant Secretary of the Navy (Installations and Environment) (ASN(I&E)) has been appointed as the Designated Agency Safety and Occupational Health Official (DASHO) for the Department of the Navy (DON). DASHO responsibilities are outlined in the Secretary of the Navy (SECNAV) Instruction 5100.10G (DON Safety and Occupational Health Policy), regarding implementation of the total safety and occupational health program for the Navy. The Navy Occupational Safety and Health (NAVOSH) Program is actually a major component of the total program. SECNAV Instruction 5100.10G delegates the authority for the operational aspects of the NAVOSH Program to the Chief of Naval Operations (CNO) who is specifically responsible for the issuance of appropriate implementing directives.

The Navy OSH Program: Policy (from OPNAVINST 5100.23D)

It is Navy policy to provide a safe and healthful workplace for all personnel. These conditions shall be ensured through an aggressive and comprehensive NAVOSH Program fully endorsed by the Secretary of the Navy (SECNAV) and implemented through the appropriate chain of command. The program shall include the following features:

a. Compliance with applicable standards

b. At least annual OSH inspections of all workplaces by qualified OSH inspectors

c. Prompt abatement of identified hazards. To the maximum extent practicable, all hazards shall be eliminated or minimized through engineering or administrative controls. Where engineering or administrative controls are not feasible, appropriate personal protective equipment (PPE) shall be provided at government expense. Where hazard abatement resources are limited, priorities shall be assigned to take care of the most serious problems first. Appropriate notices shall be posted to warn employees of unabated serious hazards and to define interim protective measures.

d. Procedures for all personnel to report suspected hazards to their supervisors and/or safety and health officials without fear of reprisal. Allegations of reprisal for such participation shall be filed per existing grievance procedures.

e. Appropriate OSH training for all safety and health officials, supervisory and management personnel, and employees. Applicable OSH requirements shall be integrated into training programs as well as into technical and tactical publications.

f. Procedures to review, in advance of construction and procurement, the design of facilities, systems, and subsystems to ensure that OSH hazards are eliminated or controlled throughout the life cycle.

g. Thorough mishap investigations and a comprehensive OSH management information system which provides all OSH data required by higher authority

h. Comprehensive occupational health surveillance programs, both medical and industrial hygiene, implemented by qualified personnel, including:

    (1) Industrial hygiene surveillance programs that identify and monitor potential hazards in the workplace

    (2) Medical surveillance programs that monitor employees who are exposed to potential hazards

(3) Periodic review of employee placement in medical surveillance programs to ensure that necessary tests are given and unnecessary tests are deleted

(4) Trend analysis to identify increasing exposures or groups of employees exhibiting the same medical symptoms

(5) Occupational medicine investigations of selected patient signs and symptoms to identify previously unrecognized sources of exposure in the workplace

(6) Integration of the various medical and industrial hygiene specialties into a team approach to promote an aggressive, proactive occupational health care system.

i. Procedures consistent with Office of Personnel Management (OPM) and Bureau of Naval Personnel (BUPERS) directives to recognize superior or deficient OSH performance. Performance evaluations shall reflect personal accountability in this respect, consistent with the duties of the position, with appropriate recognition of superior performance, and conversely, adverse notation or administrative action, as appropriate, for deficient performance.

The Navy OSH Program: Program Elements

The Navy's OSH program elements consist of:

- TRAINING: To instruct individual employees to perform their work in a safe and healthful manner; to train employees on the specific hazards and safe work practices for the hazardous material and chemicals they use in the workplace; to train managers to enable them to effectively support OSH programs in their areas of responsibility; to train supervisors to recognize unsafe and unhealthful working conditions and work practices in the workplace and to manage the OSH program at the work unit level; to train activity OSH personnel to effectively monitor and guide the activity's OSH program.
- HAZARDOUS MATERIAL CONTROL and MANAGEMENT (HMC&M): Preventing or minimizing the introduction of hazardous material (HM) into the Navy system; the safe use of HM in the workplace; and the safe handling and disposal of hazardous waste (HW).
- OCCUPATIONAL HEALTH: Primarily concerned with the more insidious health effects, usually produced by long-term (chronic) exposures to occupational hazards, e.g. toxic chemicals or harmful physical agents (e.g. noise, radiation). The Occupational Health aspects of the OSH program consists of Industrial Hygiene (the identification and evaluation of occupational health hazards and the recommendation of practical controls to lower workplace health risk) and Occupational Medicine (the medical surveillance of employees potentially exposed to workplace hazards).
- INSPECTIONS: To identify hazardous conditions, unsafe work practices and violations of standards.
- EMPLOYEE REPORTS OF UNSAFE/UNHEALTHFUL WORKING CONDITIONS: Identification and reporting of potentially unsafe or unhealthful working conditions is the responsibility of all Navy employees, military and civilian. They shall be encouraged to report, orally or in writing, unsafe or unhealthful working conditions to their immediate supervisor, who shall promptly investigate the situation and take appropriate corrective actions.
- DEFICIENCY (HAZARD) ABATEMENT: To eliminate or control in a systematic manner, workplace deficiencies that are identified through workplace inspections or employee hazard reports.
- MISHAP INVESTIGATION: Investigation of mishaps that result in occupational injury, illness or death of Navy civilian or military personnel, or damage to Navy facilities or equipment, to identify causes and corrective action.

- RESPIRATORY PROTECTION: Protecting personnel from exposure to potentially hazardous airborne contaminants, which can be dangerous if inhaled.
- ASBESTOS CONTROL: Controlling or eliminating Navy personnel exposure to asbestos during the use, removal and disposal of asbestos materials.
- HEARING CONSERVATION AND NOISE ABATEMENT: To prevent occupational hearing loss resulting from exposure to hazardous noise environments, e.g. forging hammers, grinders, saws, internal combustion engines, gunfire, rocket fire, marine engines and a myriad of noise sources in industrial activities.
- SIGHT CONSERVATION: Protecting personnel exposed to eye hazardous areas or operations, e.g. pouring or handling molten metals or corrosive liquids, cutting, welding, drilling, grinding, sand blasting.
- PERSONAL PROTECTIVE EQUIPMENT (PPE): Personal Protective Equipment (PPE) shall be employed to reduce or eliminate personnel exposure to workplace hazards, when engineering controls, the primary method to eliminate or minimize hazard exposure, are not practicable.
- LEAD CONTROL: Preventing lead intoxication and related injuries during the use, handling, removal and melting of materials containing lead.
- NON-IONIZING RADIATION: Protecting personnel from laser radiation, which encompasses the ultraviolet, visible and infrared portions of the electromagnetic spectrum. Lasers are used in such applications as communications, range finding, guided munitions, welding, cutting and medical treatment.
- ERGONOMICS: Preventing injuries and illnesses resulting from workplace ergonomic hazard conditions that pose a biomechanical stress to a worker's body as a consequence of posture and force requirements, work/rest regimes, repetition rate, etc.
- ENERGY CONTROL (LOCKOUT/TAGOUT): Locking out or tagging out the sources of energy to machinery or equipment, to prevent unexpected energization or movement during servicing or maintenance.
- POLYCHLORINATED BIPHENYLS (PCBs): Minimizing the exposure of personnel to PCBs during the use, removal and disposal of PCBs and PCB-containing materials, arising from such processes as retrofitting PCB-containing electrical transformers, removing PCB-impregnated felts or gaskets, or working with synthetic rubber, plasticizers or other PCB-containing materials.
- MAN-MADE VITREOUS FIBERS: Controlling and minimizing personnel exposure to man-made vitreous fibers (MMVF, also man-made mineral fibers, MMMF), which are fibrous inorganic materials, generally aluminum or calcium silicates, that are derived from rock, clay, slag or glass, and which are widely used for thermal and acoustical insulation and as reinforcement materials.
- CONFINED SPACE ENTRY/GAS FREE ENGINEERING: Navy policy is that all confined spaces are considered hazardous and entry into or work on the boundaries of such spaces is prohibited until the space has been evaluated and appropriate safety precautions established. Confined spaces are enclosures that are not designed for routine occupancy but are large enough or so configured that an employee can enter to perform work. Generally, such spaces are poorly ventilated, have limited or restricted means for entry or exit, and contain potential or known hazards.
- BLOODBORNE PATHOGENS: Protecting personnel from occupational exposure to bloodborne pathogens, principally human immunodeficiency virus (HIV) and hepatitis B virus (HBV).
- OCCUPATIONAL REPRODUCTIVE HAZARDS: Protecting personnel from occupational stressors (biological, chemical or physical) that have the potential to adversely affect the human reproductive process.

- INDOOR AIR QUALITY: Increasing the level of comfort and productivity in the workplace, by controlling such factors as temperature and humidity, carbon dioxide levels, off-gas chemicals, tobacco smoke and biological contamination.

Because of activity size and mission, including the size of the OSH office or availability or non availability of OSH professionals in primary or remote locations, some shore activities may be involved in host/tenant agreements where-in specifically identified OSH functions are performed by personnel from another activity (i.e., Naval Hospital or clinic, host activity OSH office, and in rare instances through contractor support services).

The NAVSEA Shore Activity OSH Program

As discussed above, NAVSEA shore activities are involved in a wide variety of industrial and non-industrial functions. Personnel may be required to work in environments that contain a wide range of circumstances involving the risk of occupational injury and illness. So how do NAVSEA shore activities protect their employees?

OSH is everyone's responsibility; everyone is responsible for working in a safe manner, in accordance with prescribed policy, guidance, rules and procedures; and for identifying and reporting unsafe conditions to the proper organizational element. While the shore activity's OSH office is instrumental in providing OSH program policy and guidance, and interpreting Navy and regulatory (e.g. OSHA and EPA) rules and regulations, all organizational elements are responsible for the effective execution of the OSH program.

Effective OSH program management begins at the top. The shore activity Commanding Officer is charged with the responsibility to establish a positive organizational and workplace environment that facilitates effective execution of the activity's OSH program. OSH program elements and initiatives currently and routinely employed at NAVSEA shore activities include:

- periodic scheduled and unscheduled workplace inspections
- industrial hygiene surveys
- periodic CO/senior manager "zone" inspections
- annual and special event safety standdowns
- feedback mechanisms for reporting observations of unsafe conditions/unsafe acts
- designing OSH concepts into work processes/standard operating procedures
- CO-chaired OSH steering committees
- Combined OSH and Environmental (HMC&M) committee meetings
- work group (shop, department, etc.) OSH committees
- general, functional and task specific OSH training
- activity newsletter articles
- OSH strategic planning /Annual OSH Program Improvement Plan reviews and updates
- Safety awards and recognition programs
- Three level (3 tier) hierarchy of OSH inspections
  - activity annual self-evaluations
  - headquarters evaluations (triennial)
  - Navy Inspector General inspections
- Inspections by federal regulators
- Mishap investigations & root cause analysis

OSH Program Measurement

Perhaps, the most visible indicator of a healthy occupational safety and health program is the absence of injury and illness in the workplace. But, this is not necessarily proof positive that a responsible, pro-active and effective OSH program is in place. Even during periods of seemingly sheer neglect, circumstances and even luck could combine to produce a period of relative calm free from accident and injury.

Traditionally, the Navy and NAVSEA OSH programs have focused on a number of set bench marks as indicators of program viability including:

- Injury and Illness Rate (IIR) both reportable (to the Navy Safety Center) and non reportable events (first aid treatment and release, as well as clinic and hospital admissions relative to days of lost time due to illness and/or injury). IIR covers all <u>recordable</u> events (fatality, lost time, no lost time and first aid).
- Frequency Rate (FR) for reportable incidents for lost workday cases only
- Severity Rate (SR) for reportable incidents away from work only

- Federal Employee Compensation Act (FECA) costs for medical and compensation expenses and salary (deemed payable by the Department of Labor) for lost time from work

However, while these benchmarks have served the program well to frame the overall dimensions of the Navy OSH program and provide a standardized set of variables to compare programs among activities, we now recognize that these indicators in and of themselves are not enough. For example, initial attempts to evaluate an activity that reports over 400 eye injuries and only 26 back injuries during a stated reporting period could be misleading. At first glance, eye injuries appear to stand out above back injuries. But, a closer examination might reveal that most eye injuries result in only one to two hours lost time requiring a simple eye wash or flushing to remove foreign objects and effectively no compensation costs. While back injuries generally are associated with injuries of a much more serious nature resulting in costs exceeding $25,000 dollars at the low end of compensation to several hundreds of thousands of dollars at the high end for each occurrence.

Accordingly, the Navy has commissioned a special Total Quality Leadership (TQL) panel to establish new, more revealing measurement guidelines to enable field activity program managers and higher echelon commanders to better gauge the effectiveness of their OSH programs and more readily identify strengths and weaknesses including strengthening root cause analysis. In addition, both the Navy and NAVSEA have adopted strategic plans to further OSH programming and policy.

OSH Program Management During Downsizing, Realignment And Base Closure

With the advent of workplace downsizing, activity realignment and base closures, the impact on activity OSH program management has been dramatic. Personnel losses in the workplace (fewer people to do tasks previously intended to be accomplished by greater numbers), as well as the reductions in staffing in the OSH program offices mean fewer people to effect the day-to-day oversight and review of work practices, provide training, and conduct inspections/audits to ensure proper health and safety practices are in place and being maintained. Further, with the loss of experienced personnel and reassignment of personnel from one shop to another or one function to another, the potential for increased injury is a very serious concern. Fewer people overall, including reductions in the OSH office, impact training and supervision regarding employees doing tasks they may not be properly qualified to undertake.

So, too, during base closure, employees are faced with undertaking a host of new functions and tasks that are very different from the normal day-to-day operations of field activities including: moving equipment and material not normally to be moved; dismantling equipment, facilities; cleaning up spaces and grounds from the effects of hazardous material spills; repackaging and sealing open containers of hazardous materials for removal and shipment from the activity; operating special equipment and machinery associated with closure that is not part of the regular equipment and machinery fleet; physically lifting and handling large quantities of equipment and material in contrast to dealing with small quantities in measured increments with respect to regular tasks and processes; energizing and deenergizing equipment and machinery in sequences outside their normal routine. Each of these examples and many more too numerous to list pose new safety risks, dangers and challenges to the well being of the activity OSH program. Such events serve to further stress the importance that OSH is everyone's concern, not only the supervisors and OSH office staff, but each and every employee, regarding his or her own well being and also the well being of their fellow workers.

The OSH Challenge

Just as it is Navy and NAVSEA policy to provide a safe and healthful workplace for all employees and the responsibility of the command to carry out this policy, it is incumbent upon all of us (supervisors, workers, managers, line and staff) to take the initiative to:

- ensure proper training before initiating or undertaking a specific task or function;

- understand the hazards associated with the task at hand;
- be tested and fitted with the proper personal protective equipment necessary to undertake a given task safely;
- use the proper personal protective equipment provided in the proper manner;
- promptly notify management and co-workers when there is a problem or suspected problem regarding injury and illness in the workplace;
- report all incidents no matter how trivial and seek prompt medical attention;
- receive appropriate Hazard Communication (HAZCOM) training for every new hazardous material and new formulation of existing hazardous materials used in the workplace;
- report regularly for testing and evaluation if part of a medical surveillance program;
- maintain appropriate physical fitness to undertake the tasks and functions assigned and, moreover, advise supervisors and co-workers if there is a problem or potential problem associated with the conduct of the intended task that could cause injury or harm;
- freely participate in the activity beneficial suggestion program to contribute ideas and recommendations to improve the workplace and advise of health and safety concerns;
- observe all health and safety rules and regulations, regardless of the temptation to take shortcuts or save time; and,
- take pride in the quality of your workmanship and your contribution to America's national defense.

***Thomas Grossman** is Deputy Director of the NAVSEA Shore Activity Environmental and Occupational Safety and Health (OSH) Office and also that Office/s Branch Head. He is a 1961 graduate of the U. S. Merchant Marine Academy, Kings Point. He has been employed at NAVSEA and its predecessor organizations since 1966 in a variety of engineering and management positions, primarily in the areas of naval ship construction and maintenance workload planning and execution. He completed the resident program at the Industrial College of the Armed Forces in 1982. He established the Navy Asbestos Litigation Support Office in 1982 and was Director until 1986, at which time he became Deputy Chief of Staff of NAVSEA's Industrial and Facility Management Directorate. He has been in his current position since 1988.*

Regionalization of Supply Through Partnerships

Bob Tomasik
Industrial Support Division
NAVSUP 422
Naval Supply Systems Command

Hank Lavender
Senior Business Analyst and Project Manager
AmerInd, Inc.

Approved for Public Release
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Abstract

Department of Defense budget reductions and downsizing activities have created numerous initiatives within the Navy to find ways to reduce operations and maintenance costs in order to preserve war fighting force structure. NAVSUP and NAVSEA agreed to analyze the feasibility and benefits of establishing "partnerships" between NAVSUP Fleet and Industrial Supply Centers (FISCs) and NAVSEA field activity supply departments.

The primary objective of any potential partnership between a FISC and a NAVSEA field activity supply department is to reduce the costs of providing supply support to NAVSEA supply department customers while maintaining the same or better level of performance in providing that support. NAVSUP has developed a Business Case Analysis (BCA) approach which compares the costs and performance of current NAVSEA field activity supply departments with the projected costs and performance of supply operations in partnership with a FISC.

This paper addresses the vision and strategy of NAVSUP for promoting regionalization of Navy supply; the methodology used to perform partnership BCAs; some practical considerations of the methodology for the development of NAVSUP FISC and NAVSEA field activity supply partnerships; and the results obtained to date with Supply Department - FISC partnerships at Naval Weapon Stations and Naval Shipyards.

List of Figures and Tables

Abbreviations

AMIS	Automated Management Information System
ABC	Activity Based Costing
BCA	Business Case Analysis
CONOPS	Concept of Operations
DoD	Department of Defense
DON	Department of the Navy
FEA	Functional Economic Analysis
FISC	Fleet and Industrial Supply Center
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
NAVSEA	Naval Sea Systems Command
NAVSUP	Naval Supply Systems Command
NAVORDCEN	Naval Ordnance Center
NSY	Naval Shipyard
NWS	Naval Weapons Station

Background

In response to large reductions in defense budgets during the 1990s, DoD has engaged in a major ongoing review of the organizational structures and business processes of the department and the military services in an effort to find ways to reduce operational costs and preserve essential levels of warfighting force structure in support of the national defense strategy. Functional support activities such as training, acquisition, logistics, medical, installation operations, etc., have been targeted for major cost reductions to be achieved through streamlining, reengineered business processes, consolidations, and commercial outsourcing where it makes sense.[1] The DoD *Bottom Up Review* tapped all service central logistics functions, which include depot maintenance, supply management, and transportation activities, for $30 billion in savings from FY 92 through FY 97.[2] The *1995 Report of the Commission on Roles and Missions of the Armed Forces* contains recommendations for the privatization of all depot maintenance activities as well as selected material supply management functions such as cataloging, inventory management, and warehousing.[3] Defense Secretary William J. Perry is expected to act upon recommendations to contract out materiel supply management functions after the completion of a Pentagon review of the Commission's report.[4]

In the face of these realities, DON has actively encouraged all Navy support organizations to find ways to reduce the costs of Naval support operations and infrastructure. NAVSUP has responded with an aggressive campaign for marketing the expertise, skills, and capabilities of its FISCs to provide cost effective, streamlined and efficient material management support to all Naval supply customers. The details are contained within NAVSUP's *Strategic Plan* for the future development of the Navy Supply System.

NAVSUP Vision and Strategy

The NAVSUP *Strategic Plan* provides the framework and roadmap for the future evolution of the Navy Supply System to become the premier provider of logistics services and material support needs of all Naval activities. The focus of this plan is to make the Navy Supply System a customer-driven organization totally responsive to customer requirements and is reflected in the plan's mission, vision, and supporting strategies:[5]

The mission of the Navy Supply System has remained constant for over 200 years:

> *"To provide our Naval Forces quality supplies and services."*[6]

But while the mission has remained unchanged, the means and methods of executing the mission are constantly changing and improving through the introduction of modern management processes and technology as the Naval Supply System keeps pace with the increasing demands that are being placed on our Naval forces to protect US national interests throughout the world. The desired end state of this process of continuous improvement is articulated in NAVSUP's vision for the Naval Supply System:

NAVSUP Vision

> *"We will transform today's infrastructure - intensive supply system into a lean, process - driven system where a single action by the customer activates a global network of sources that delivers best value products and services. In short...'One - Touch Supply'."*[7]

"One -Touch Supply" means that a customer will need only a single access point into the Naval Supply System to select from a broad range of products and services. And from the customer's perspective, the processes by which these products and services are delivered will be "invisible". The *Strategic Plan* identifies five critical issues that NAVSUP will take the lead in addressing over the next five years to achieve this vision of "One-Touch Supply":

- *"Driving down the cost of supply infrastructure.*
- *Reducing weapon system life cycle support costs and supporting inventory investment.*

[1] Report of the DoD Commission on Roles and Missions of the Armed Forces, *Directions for Defense,* 24 May 1995, Chapter 3.
[2] Report of the OSD Bottom Up Review, *Infrastructure Review, Task 2,* 1 April 1993, pg. D-3.
[3] op. cit., *Directions for Defense,* pgs 3-9,10.
[4] Meadows, Sandra I., "*Push to Privatize Pentagon Work Gathers Wide Support*", National Defense, October 1995, pgs. 11-13.
[5] NAVSUP, *Strategic Plan,* January 1996.
[6] op. cit., *Strategic Plan*, pg. 3.
[7] op. cit., *Strategic Plan*, pg. 3.

- *Partnering with the Fleet to reduce the cost of afloat supply and supporting infrastructure.*
- *Driving down cycle time for satisfying customer contracting requirements.*
- *Building a skilled and flexible workforce around new processes, systems and training mechanisms."*[8]

NAVSUP has developed a series of five strategic initiatives to deal with each of these issues. The first is designed to specifically attack the ashore infrastructure to make it more efficient and free resources for the afloat mission. The goal of this initiative is to:

> *"Drive down the cost of supply infrastructure and transform the system into a responsive global network."*[9]

The goal will be achieved through the execution of three key strategies:

> *1. Complete Regional Supply through strategic partnerships.*
>
> *2. Take Regional Supply national, creating a single, process-driven system.*
>
> *3. Link the process-driven system to best value providers of products and services accessible through a single customer action."*[10]

The unifying theme that links all of the strategic initiatives and their supporting goals and strategies into a comprehensive and integrated action plan can be stated in a word-- Partnerships. Partnerships are essential in order to take into consideration the functional responsibilities of Naval entities not under the control of NAVSUP.

NAVSUP Fleet and Industrial Supply Centers are implementing agents for achieving the goals and objectives of the *Strategic Plan.* Each FISC is charged with the responsibility of marketing partnerships with other Naval activities within their region who are presently managing and performing their supply functions independently. The intuitive expectation for such partnerships is that they will streamline Navy supply infrastructure and reduce overall costs through economies of scale and process improvements as a result of the consolidation of supply functions and processes which are common to both parties, **without sacrificing the level of support to end use supply customers**. However, these expectations must first be validated and this is accomplished through a thorough examination of the technical feasibility and financial consequences of proposed partnerships. The product of this examination is a Business Case Analysis.

BCA Methodology

The BCA methodology jointly developed by NAVSUP and AmerInd, Inc. is a tailored and modified analysis based on the principles and techniques found in DoD 8020.1-M, *Functional Process Improvement* and DoD's Corporate Information Management *Functional Economic Analysis Guidebook,* Version 1.1. The BCA includes elements of activity and process analysis, and activity based costing in the development of first, an As-Is model of a prospective partner's current supply operation that completely describes business processes and costs of operations, and secondly, the construction of a To-Be model describing the business processes and costs of operation of a proposed FISC partnership. The results of the BCA are published in a final report that compares current operations to proposed partnership operations in terms of business processes, costs, customer support, and impact on infrastructure. The actual conduct of the BCA is performed by a BCA Team composed of functional experts from both the FISC and the prospective partner. The BCA Team receives its direction and guidance through a Charter promulgated by the corporate sponsors of the analysis- in this case NAVSUP and NAVSEA. The key elements of the charter are:

BCA Mission. A clear statement of the BCA mission describing the problem to be solved and the role of the BCA analysis in the solution of the problem.

- **BCA Objectives.** An enumeration of the specific goals and objectives of the BCA such as the production of a comprehensive comparative financial analysis, the description of current and proposed business practices, and the identification of potential implementation issues.

- **BCA Boundaries.** A description of the intended scope of the proposed partnership in terms of the business functions, processes and organizations to be analyzed as well as all known assumptions and con-

[8] op.cit., *Strategic Plan*, pg.4.
[9] op.cit., *Strategic Plan*, pg. 7.
[10] op.cit., *Strategic Plan*, pg. 7.

straints that the BCA Team must adhere to in the conduct of the analysis.

- **Schedule of Events.** Provides for a formal start date; dates for progress reports, staff consultations and interim briefings; and the date and format of the final decision briefing and BCA report.

The BCA can be partitioned into three distinct phases: 1. Developing the As-Is or baseline case; 2. Developing the To-Be case or partnership proposal; 3. Preparing the partnership implementation plan (assuming the BCA supports a partnership, and the potential partner agrees to it).

◊ Building the As-Is Model

The As-Is case involves characterizing the prospective partner's supply operations through the collection of business data (financial, workload, performance, and standards) that will enable the BCA Team to build a quantifiable picture of the total supply business. The effort with respect to data describing workload, performance, and standards, while often tedious and time consuming, is still a fairly straight forward process of referring to historical databases and/or interviewing key personnel as needed. However, capturing the costs of operations is not so straight forward.

DoD, as well as Navy, financial accounting systems have traditionally focused on developing, distributing and capturing financial requirements and expenditures either by organizational element or budgetary accounts. These systems were designed for organizational entities to forecast their resource needs for the development and justification of budget requirements, and then to track the effectiveness of budget execution. (Figure 1.)

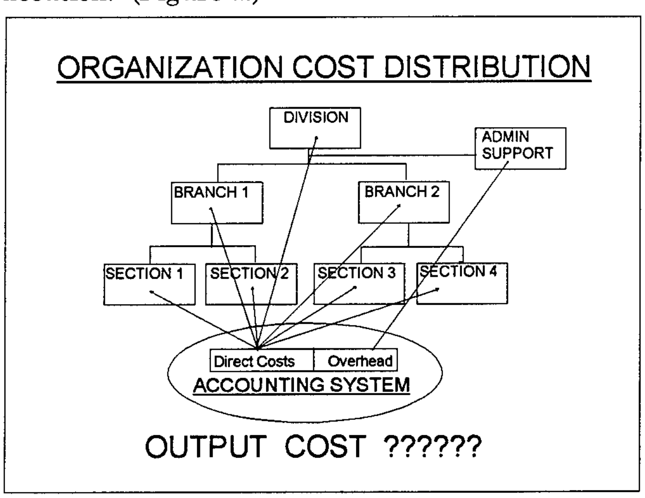

Figure 1.

In general these organizational based accounting systems are ineffective in accounting for the true total cost (direct labor, direct material, and overhead) of a business activity involved in producing a specific product or service. In particular, they do not provide for an accurate or equitable distribution of overhead costs to individual activities and processes. (Figure 2.)

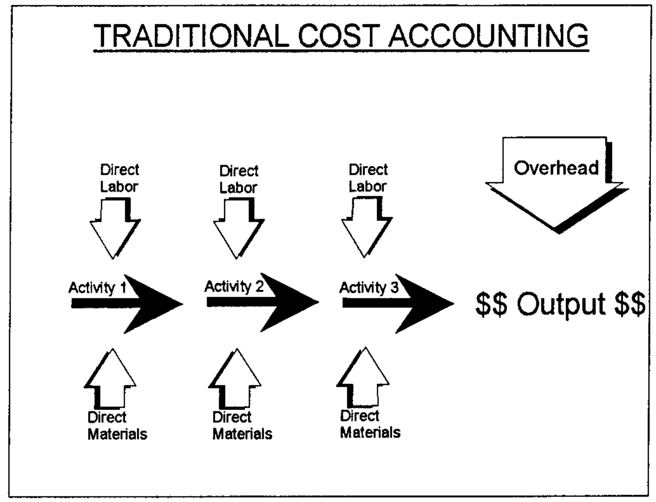

Figure 2.

However, to be sure that a fair and accurate comparison of operational costs between the As-Is case and the To-Be case is developed, a common frame of reference must be established for comparing As-Is case costs to the To-Be proposal costs. This is accomplished by portraying the partner's supply department in terms of the type of work (or business processes/activities) it performs as opposed to its organizational structure. Figure 3 depicts a notional organizational arrangement for a Generic Supply Department, while Figure 4 depicts the same Generic Supply department in terms of its business activities.

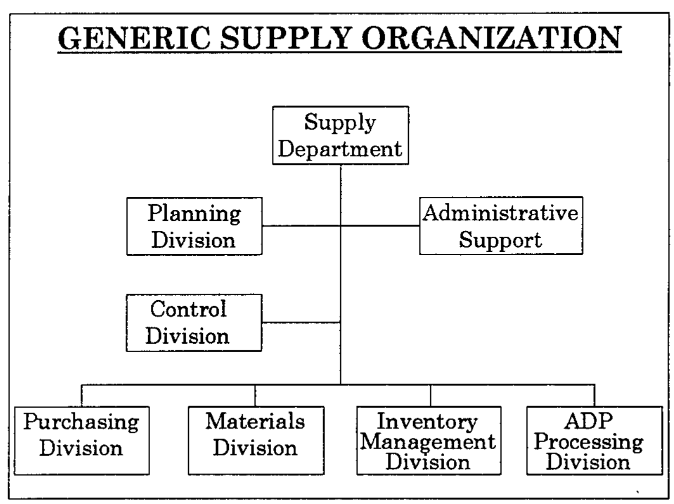

Figure 3.

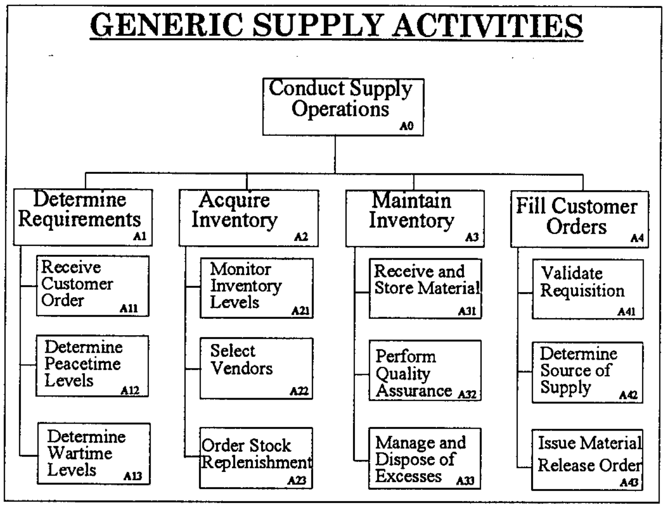

Figure 4.

Activity Based Costing (ABC) is an accounting technique that provides the means for creating a fair and accurate cost comparison between the As-Is and To-Be models. (Figure 5.) To employ this method, the BCA Team must first analyze the partner's supply operation to identify the distinct business activities that will be considered for a partnership arrangement. A narrative describing the functional processes (what work is accomplished and how it is accomplished) for each business activity should be developed to provide a basis for insuring that the business processes in the To-Be proposal fulfill the requirements of the activity. Then the BCA Team must collect the relevant data for each activity that describes the amount of work performed, required standards of work performance, actual achieved level

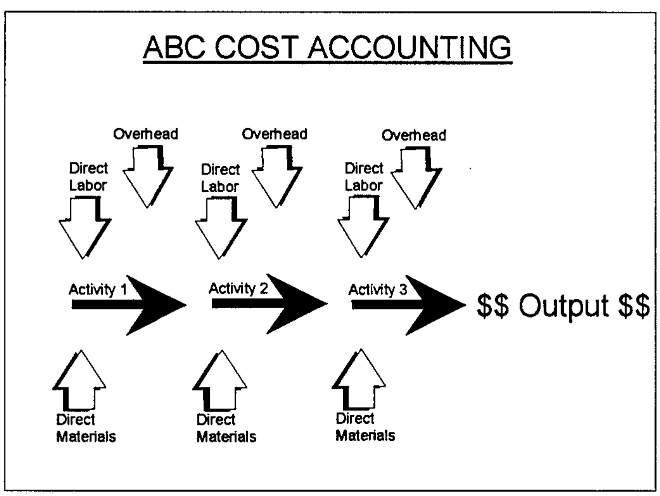

Figure 5.

of work performance, and the total costs incurred in performing the work. The task of transposing cost data found in organizational accounting databases to the activity model (Figure 6.) is the most difficult task in building the As-Is model.

BCA CHALLENGE:
MAPPING ORGANIZATIONAL COSTS TO ACTIVITY COSTS

Organizational Accounting View of a Generic Supply Department

Personnel	$ 500,000
Material	$ 50,000
Facilities	$ 75,000
ADP	$ 100,000
Contracts	$ 150,000
Other	$ 80,000
Total	**$ 955,000**

ABC Accounting View of a Generic Supply Department

Receive Customer Order	$ 75,000
Determine Inventory Levels	$ 60,000
Select Vendors	$ 70,000
Order Stock Replenishment	$ 85,000
Monitor Inventory Levels	$125,000
Receive & Store Material	$ 90,000
Perform Quality Assurance	$ 60,000
Manage/Dispose of Excess	$110,000
Validate Requisitions	$ 80,000
Select Source of Supply	$ 95,000
Issue Material	$ 105,000
Total	**$ 955,000**

Figure 6.

This task requires knowledgeable personnel who are functional experts in the business activities under analysis to insure that all costs are captured and accurately allocated to the appropriate activities including each activities' appropriate share of the supply department's overhead costs.

The final products of the As-Is case development will be: (1) a set of As-Is Business Activity Profiles for each business activity which completely describes the work performed by each activity and, (2) an As-Is Activity Based Cost Matrix that reflects the costs incurred by each activity by cost categories. Figure 7 is an example outline of a typical business activity profile.[11] The format should be tailored to fit the needs of the business activities under analysis. Figure 8 is an example of an activity based cost matrix for the As-Is case.

[11] The format was developed by the Puget Sound BCA Team for their analysis.

Business Activity: Warehousing

1. **Business Profile** (Hours per day, days per week)
   Dayshift Monday - Friday
2. **Workload / Performance Goal / Actual Performance**

Type	Workload	Standard	Performance
Issues	600-800 / mo	3 days	2.5 days
Receipts	700-900 / mo	3 days	4.0 days

3. **Personnel** (Staffing and Labor Costs): $ 265,000

Position	Auth	On-Board
GS-9	1	1
WG-7	4	3
WG-5	3	2

4. **Non-Labor Costs:** $ 176,000
   (Itemize the cost of materials, equipment, and facilities necessary to perform the warehousing activity.)
5. **Processes Used:**
   (A narrative description of how each of the work processes are performed in accomplishing the warehousing activity.)
6. **Remarks:**

Figure 7.

AS-IS ACTIVITY BASED COST MATRIX

Cost Elements \ Supply Activities	Activity One	Activity Two	Activity Three	Activity Seven	Activity N th	Totals
Personnel						
Material						
Facilities						
Information Technology						
Other						
Totals						

Figure 8.

◊ Building the To-Be Model

The To-Be model involves carefully analyzing the As-Is business activities with a view to how those activities might be operated in a partnership with the FISC. This analysis results in a partnership concept of operations (CONOPS) which describes, in the same level of detail used in the As-Is case, the business processes and resources required to operate each of the supply activities. The primary objective of the To-Be CONOPS is to describe a set of partnership business processes that will continue to provide supply department customers high quality supply support that meets or exceeds performance standards for the analyzed supply activities. If there are any reductions in the To-Be operational costs, they will be reflected in the analysis to the extent that the CONOPS is able to incorporate cost reducing efficiencies such as the consolidation of FISC/partner workload, or the introduction of automation for manual processes, or reduction of required levels of inventory, etc.

The output products of the To-Be model are the same as those developed in the As-Is model-- a set of To-Be Business Activity Profiles and a To-Be Activity Based Cost Matrix. However, the To-Be Activity Based Cost Matrix must also include a provision for capturing any initiative, or investment costs that might be required to implement the partnership, such as a one time purchase of ADP hardware to introduce a streamlined, more cost effective automated business process, or perhaps some additional one-time training necessary to qualify personnel in a new business process. (Figure 9.)

TO-BE ACTIVITY BASED COST MATRIX

Cost Elements \ Supply Activities	Activity One	Activity Two	Activity Three	Activity Seven	Activity N th	Totals
Personnel						
Material						
Facilities						
Information Technology						
Other						
Sub-Totals						
Investment						
Totals						

Figure 9.

Investment costs for non-capital investments are reflected in the data as fully expensed at the time incurred. Capital investments are amortized in accordance with appropriate DoD standard amortization schedules.

Because the To-Be CONOPS will describe the proposed operations of a future partnership, it will necessarily be based on assumptions and projections on how effective supply operations will be under the partnership CONOPS. The BCA Team must insure that all such assumptions and projections are fair and reasonable, and to the extent possible, based on objective historical facts and data. The prospective partner must be satisfied that the proposed partnership business processes will be able to meet required standards of performance for high quality customer support.

◊ **Implementation Planning**

Assuming that the BCA in fact produces positive support for establishing the proposed partnership, the next step for the BCA Team is to produce a partnership implementation plan. In order that supply activity customers do not experience any degradation in the level or quality of their supply support as a result of activating the partnership, it is critical that the introduction of partnership operations occur in a manner that is totally transparent to supply activity customers. This will require a period of transition to smoothly introduce the new or revised business processes that are described in the partnership CONOPS. So the implementation plan will be a time phased action plan describing the required events from initial startup to achieving a mature partnership operation. This means that any expected cost reductions described in the To-Be model will not be fully realized until the partnership reaches maturity. The implementation plan should include a projected cost profile for the transition period as in the example in Figure 10.

BCA Cost Findings
(Year 1 Constant Dollars)

($ Thousands)	Year 1	Year 2	Year 3	Year 4	Year 5	Totals
As-Is Model Operating Costs	11290	11290	11290	11290	11290	56450
To-Be Model Operating Costs	10480	9630	8460	8460	8460	45490
To-Be Model Investment Costs	920	450	0	0	0	1370
To-Be Model Total Costs	11400	10080	8460	8460	8460	46860
Total As-Is Costs	11290	11290	11290	11290	11290	56450
Total To-Be Costs	11400	10080	8460	8460	8460	46860
Annual Difference	-110	110	2830	2830	2830	
Cumulative Difference (Savings)	-110	0	2830	5660	**8490**	

Figure 10.

Partnership Development

The results of the BCA, though central to the decision making process and key to the cost analysis, must be supplemented by thoughtful and careful handling of a number of additional dynamics that must be skillfully managed in the development of successful partnerships:

- **BCA Team Building.** The FISC and the prospective partner must examine and evaluate each other's operations to determine whether or not there is indeed a benefit to be derived for both parties to combine their operations into a partnership. Both parties have valid concerns that should be fully and openly addressed in the analysis. For the FISC's part, their primary concern is that the BCA accurately account for <u>all</u> of the partner's current business processes and operations costs. The risk to the FISC in failing to do so, is the inheritance of additional financial liability after the development of a partnership which later turns out to be more costly to operate because of hidden costs that were not identified in the BCA. On the prospective partner's part, the major concern is that the BCA CONOPS for partnership operations is realistic and fully accounts for all of the costs and resources required to implement it. The risk for the partner is degraded customer supply support because of overly optimistic partnership cost and resource projections that result in the FISC's inability to meet the standards of performance required to insure continuous high quality support to the partner's supply customers. These kinds of issues and/or concerns can be greatly mitigated by paying attention to some simple but effective steps for creating confidence, trust, and cooperation between and among the members of the BCA Team:

◊ **Team Composition.** To the extent possible, team membership should consist of equal numbers of people from both the FISC and the prospective partner. Experts in the same functional activity from both parties should be paired to work together on their assigned portions of the analysis. This contributes to developing an understanding of each other's respective processes and concerns and should ultimately enhance the credibility of the analysis.

◊ **Team Training.** The time required to conduct the BCA will vary from as little as 6-8 weeks to as much as six months, or more, depending on the magnitude and complexity of the contemplated partnership. While the team members will be functional experts in their respective areas of supply management, the methodology for performing the analysis will likely be unfamiliar to them. The team must be trained in the methodology and how it will be applied to their specific analysis. Such training should not require more than about two days and will go a long way toward insuring that the team will be operating within a common analytical framework and functional language, which should increase their confidence levels and enhance cooperation.

◊ **Resolving Biases.** Partnering represents change to the standard way of doing business and change tends to create uncertainty and resistance in the people involved in the process. In all likelihood, the team members will bring to the analysis their own internal set of preconceived attitudes and concerns about the kinds of changes the proposed partnership will create if implemented. (Fears of possible job loss; reduction in grade or authority; need to relocate; need for retraining; etc.). These attitudes, if not dealt with, can often result in creating emotional barriers (conscious or unconscious) to achieving the goal of the BCA -- a completely objective business analysis of the proposed partnership that is based on verifiable facts, data, and fair and reasonable assumptions when assumptions are required. These concerns are best dealt with early in the process by taking time for an open discussion of the concerns and expectations of each of the team members. This will contribute to better understanding between the team members and hopefully create a cooperative environment for producing an objective and credible analysis.

◊ **Team Organization.** The BCA will consist of a complex set of interrelated tasks to collect and develop costs, process descriptions, workload and performance data, standards, assumptions, and constraints. Both parties have a vested interest in the quality of the collection and analysis of business case data. Therefore they must agree as a team on the collection and storage methods to be used, as well as create an internal management structure with appropriate control and feedback mechanisms to ensure data is reviewed and validated frequently during the collection process and the analysis timeline is maintained.

• **Partnership Implementation.** A completed BCA that supports the creation of a partnership is only the first step in developing that partnership. The actual partnership is implemented through Memorandums of Understanding / Agreement (MOU/MOA) between the parties that resolve many implementation issues such as "host-tenant" relationships, funding mechanisms, functional transfer procedures, allocation of personnel hiring authority, partnership performance oversight and review procedures, inventory transfer procedures and mechanisms, etc. Many of these implementation type issues will first surface during the BCA. To the degree that the BCA Team can develop suggested solutions to these issues during the course of their analysis, they should do so and include them as additional findings or recommendations in the BCA Report. However, intractable implementation issues that do not affect the outcome of the BCA should not be permitted to impede the analysis, but rather should be left to be negotiated by the parties during the development of the MOU/MOA.

NAVSUP-NAVSEA Partnerships

Early in 1994 NAVSUP and NAVSEA began to investigate ways of reducing the size and cost of Navy shore based infrastructure for supply support. NAVSUP proposed the concept of consolidating field level supply activities on a regional basis by establishing a system of partnerships between NAVSUP FISCs and the NAVSEA field activity supply departments in each FISC's respective region. NAVSEA agreed in principle with the concept provided that prior business case analysis of proposed partnerships supported projections of reduced operational costs and partnership ability to continue to deliver uninterrupted high quality supply support to NAVSEA field activities.[12]

The first BCA was chartered in June 1994 to analyze proposed partnerships between the supply departments of five NAVORDCEN[13] Naval Weapons Stations (NWS) (Earle, NJ, Yorktown, VA, Charleston, SC, Concord, CA, and Seal Beach, CA) and their respective regional FISCs. The BCA was completed in September 1994 with a positive conclusion supporting partnership projections, and partnerships were established in November 1994 with an MOA between NAVSUP and the Naval Ordnance Center (NAVORDCEN).

• Following is a summary of the essential elements of the FISC - NWS business case and the results of partnership performance to date:

◊ FISC - Weapon Station partnership lineup:

Weapons Station	FISC Partner
Earle, NJ	FISC Norfolk, VA
Yorktown, VA	FISC Norfolk, VA
Charleston, SC	FISC Norfolk, VA
Concord, CA	FISC Puget Sound, WA
Seal Beach, CA	FISC San Diego, CA

[12] NAVSEA policy letter, 11 Jan 1994, Subject: Partnerships With Fleet and Industrial Supply Centers.
[13] NAVORDCEN is an intermediate command subordinate to NAVSEA and responsible for the management and operations of Naval Weapons Stations.

◊ The scope of the BCA was restricted to only non-ordnance supply functions and included the following NWS Supply Department activities to be evaluated for a three year partnership agreement (FY95 - FY97):

- Customer Service
- Inventory Management
- Procurement
- Receipt Control
- HAZMAT Management
- Warehousing
- Packaging and Preservation
- Local Delivery
- Admin Overhead
- Automated Management Information Systems (AMIS)

◊ The major assumptions and constraints bounding the BCA were:

- The partnerships would stock, store and issue hazardous materials, but responsibility for hazardous waste collection, storage and disposal would remain with the NWSs.
- NWS Supply Department's workload would remain relatively constant through FY 97.
- NWSs would provide standard base support services on a non-reimbursable basis.
- NWS Supply Department personnel would be available to fill partnership supply manpower billets as required.
- Total cost of Supply Department operations under partnership management must not exceed funding levels forecast to be available by NAVORDCEN for fiscal years FY 95 and beyond.[14]

◊ The results of the As-Is cost analysis for the five Naval Weapons Station Supply Departments are depicted in Table 1:

	Charleston	Yorktown	Earle	Concord	Seal Beach	Totals
Customer Service	$179,378	$241,730	$138,801	$98,120	$246,386	$904,415
Inventory Management	$357,334	$739,534	$250,453	$214,648	$235,894	$1,797,863
Purchasing	$262,964	$324,259	$465,952	$208,100	$756,948	$2,018,223
HAZMAT Management	$283,389	$493,289	$10,800	$187,470	$522,502	$1,497,450
Receipt Control	$0	$343,111	$0	$229,424	$189,745	$762,280
Receiving	$0	$0	$0	$0	$223,494	$223,494
Warehousing	$411,921	$589,758	$757,484	$403,300	$177,803	$2,340,266
Local Delivery	$0	$0	$0	$0	$0	$0
Packing and Preservation	$0	$89,533	$0	$43,760	$39,680	$172,973
AMIS	$0	$143,759	$44,143	$98,420	$278,893	$565,215
Admin Overhead	$150,608	$220,955	$304,451	$220,780	$329,631	$1,226,425
Direct Workload	$125,634	$998,328	$209,884	$0	$161,047	$1,494,893
Totals	$1,771,228	$4,184,256	$2,181,968	$1,704,022	$3,162,023	$13,003,497

Table 1.

◊ The To-Be CONOPS proposal was a three phase implementation plan to take place over two years starting in FY 95, and reaching maturity in Phase Three at the beginning of FY 97. In Phase One the partnerships would start operations in an "As-Is, Where-Is" mode and begin implementing a Consolidated Hazardous Material Reutilization and Inventory Management Program (CHRIMP); minimize warehousing footprint through inventory consolidations; and initiate actions to streamline and reduce staffing levels. Phase Two would implement total process and system integration through remote online processing for inventory management, small purchasing, and customer support within an NWS "storefront" and FISC "backroom" operational concept. The partnership CONOPS would achieve maturity at the beginning of Phase Three to include fully developed NWS - FISC ADP system interfaces. The BCA As-Is and To-Be cost findings are summarized in Table 2.

FISC-NWS BCA Cost Findings
(FY 94 Constant Dollars)

($ Thousands)	FY 94 Baseline	FY 95 Phase I	FY 96 Phase II	FY 97 Phase III
NWSs As-Is Costs	$13004	$13004	$13004	$13004
NAVORDCEN Budget Forecast		$9750	$9750	$9750
BCA To-Be Partnership Costs		$9578	$9026	$7651

Table 2.

[14] To guard against the possibility of introducing bias, NAVORDCEN forecast funding levels were not made known to the BCA Team until after the analysis was completed.

Based on the favorable findings of the BCA, NAVSUP submitted a three year fixed price bid to NAVORDCEN for NAVSUP FISCs to partner with NWS Supply Departments at the BCA projected partnership costs in Table 2. During the development of the MOA, some minor adjustments were negotiated in the three year bid price. The final partnership cost profile agreed to in the MOA is depicted in Table 3.

FISC-NWS MOA Cost Ceilings
(FY 94 Constant Dollars)

($ Thousands)	FY 95 Phase I	FY 96 Phase II	FY 97 Phase III
FISC-NWS MOA Budget Profile	$9410	$8687	$7616

Table 3.

The MOA three year cost profile represents a reduction of 32.2% over the three year cost of non-partnership operations at the current As-Is ops tempo, and 12.1% below NAVORDCEN's forecast of funds availability to support NWS Supply Departments operations. Since implementation of the partnerships, the actual costs of NWSs supply operations have been even lower than predicted, while generally continuing to maintain or exceed standards of performance agreed to in the partnership MOA. Cost data is available for the first eleven months of FY 95 and is presented in Table 4. As-Is and FY 95 BCA twelve month cost data has been normalized for an eleven month comparison.

FISC-NWS BCA vs Actual Performance
(11 months)[15]

	FY 94 As-Is Baseline	FY 95 BCA/MOA	FY 95 Actuals	Difference Between FY 95 & As-Is and Actuals
As-Is vs Actuals	$11,920,332		$6,632,802	$5,287,530
BCA/MOA vs Actuals		$7,450,671	$6,632,802	$817,869

Table 4.

[15] NAVSUP/NAVORDCEN Partnership FY 95 Annual Performance Report, *Business Plan Financial Goals.*

Encouraged by the success of the FISC-Weapons Stations BCA results and subsequent partnership performances, NAVSUP and NAVSEA chartered three additional BCAs to investigate partnerships between FISCs and Naval Shipyard (NSY) Supply Departments at Norfolk, VA, Puget Sound, WA, and Pearl Harbor, HI.

- Not surprising, each of the three FISC-NSY BCAs have developed To-Be proposals based on very similar partnership CONOPS which vary only in some of their details to accommodate local factors and conditions specific to each proposed partnership. Similarities in the CONOPS are as follows:

◊ All are based on a three year proposal with a three phase transition period for partnership implementation.

◊ All three have excluded Nuclear Supply Support functions and HAZMAT Waste management from the scope of the BCA. In addition, Puget Sound excluded HAZMAT Management, Rail Car Management, and the CDA Activity; Pearl Harbor also excluded HAZMAT Management as well as all Transportation (Local Delivery) functions; and Norfolk excluded the Kitting function for on-site work at the NSY.

◊ All three are predicting various amounts of cost savings under partnership operations which are mostly generated from the following areas:

– Reduced labor requirements as a result of consolidating activities common to both partners.

– Reduction in inventory levels generated through consolidation of common items.

– Partnership process improvements made possible through the introduction of the enhanced functionality inherent in the FISC material management system, UADPS-Level 2.

The status of the three BCA's at the time of the writing of this paper, are as follows:

◊ **Norfolk:** BCA has been completed with a favorable recommendation for partnering based on a To-Be CONOPS projecting reduced costs of operations. The decision to proceed with a partnership has been made and approved, and a corporate level Partnering

MOU has been agreed to. A local MOA is in negotiations for a projected implementation date of 1 April 1996.

◊ **Puget Sound:** The BCA is complete with a To-Be CONOPS projecting lower operational costs over current As-Is costs. The report is awaiting a final decision on partnering.

◊ **Pearl Harbor:** The BCA was completed on 24 February 1996. Data collection and partnership CONOPS development supported a partnership with projected cost reductions in the first three years of \$251,246 (5 months), \$1,217,105, and \$1,448,194 respectively. The BCA report is in the final stages of preparation and will recommend a target date for partnership implementation of 12 May 1996.

The results of the cost analyses for the Norfolk and Puget Sound BCAs are presented in Table 5 and Table 6.

Norfolk FISC-NSY BCA Cost Analysis
(FY 95 Constant Dollars)

($ Millions)	FY 95 As-Is Baseline	FY 96 To-Be	FY 97 To-Be	FY 98 To-Be	% of FY 98 Reduction from Baseline
Labor	$ 10.5	$ 9.1	$ 8.6	$ 8.0	23.8%
Non-Labor	$ 2.1	$ 2.1	$ 2.1	$ 2.1	-
Totals	$ 12.6	$ 11.2	$ 10.7	$ 10.1	19.8%
Annual Savings		$ 1.4	$ 1.9	$ 2.5	
Cumulative Savings		$ 1.4	$ 3.3	$ 5.8	

Table 5

Puget Sound FISC-NSY BCA Cost Analysis
(FY 95 Constant Dollars)

	FY 95 As-Is Baseline	FY 96 To-Be	FY 97 To-Be	FY 98 To-Be
Total Costs	9,993,322	9,762,482	9,212,642	8,790,242
Annual Savings		230,840	780,680	1,203,080
Cumulative Savings		230,840	1,011,520	2,214,600

Table 6.

Observations on the BCA Process

The Partnership BCAs described in this paper are similar to, but not the same as, a full blown functional process improvement analysis as outlined in DoD 8020.1-M. They do not engage in an in-depth application of all of the elements of the functional process improvement methodology such as IDEF0 and IDEF1X modeling, ABC to the unit output level of detail, and value added/non-added analysis. The primary objective of a Partnership BCA activity/process analysis is not to necessarily reengineer the partner's business processes, but rather to examine those processes and, taking the best of them from each partner, to construct a partnership CONOPS that results in an improved and more efficient business enterprise. Identified cost reductions that accrue to the CONOPS will most likely represent only the starting point for saving resources. Once the new partnership business processes have stabilized and matured, the next step should then be to apply the full functional process improvement methodology to reengineer where appropriate in the spirit of continuous improvement.

Conclusions

The outlook for the foreseeable future is for a continuing decline in DoD budget levels with no abatement in the pressure to reduce the cost of support operations and infrastructure in all of the services. Consolidating logistics activities/functions offers the potential for generating significant savings that can be applied to preserving critical force structure. Regionalization of logistics as a strategy for beginning the consolidation process is a good one, but only where it makes sense. The BCA methodology described in this paper provides an effective tool for evaluating potential regional consolidations to decide whether they indeed make sense or not. While the examples in this paper have dealt only with supply partnerships, the methodology has equal application to partnerships between any logistics organizations such as intermediate or depot maintenance, transportation, contracting, etc.

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Biographies

***Bob Tomasik** has 28 years experience in supply management at Headquarters DLA and Headquarters NAVSUP. He is currently the Director of the Industrial Support Division, HQ NAVSUPSYSCOM and has held positions in supply policy planning and programming, research and development and conventional ammunition management. A graduate of the Air War College and the Federal Executive Institute, he has been engaged in business case analysis of industrial activities for the past two years.*

***Hank Lavender** is a former Air Force logistician with over 25 years of experience in command and staff positions at all levels of logistics from unit level squadron and wing maintenance, depot level maintenance and material management, to Pentagon air staff. He is a graduate of the US Air Force Academy, the Industrial College of the Armed Forces, and Southern Methodist University. His last position before retiring from the Air Force in 1993 was Director of Logistics for the Air National Guard. Since joining AmerInd, Inc. as a Senior Business Analyst and Project Manager, Mr. Lavender has been involved in supporting clients with needs for strategic planning, business reengineering, and information systems development.*